POWER PLANT ENGINEERING

Trade-mark reg. U. S. Pat. Office

SEMI-MONTHLY

VOL. XXII. CHICAGO, JUNE 15, 1918. No. 12

Mayfair Pumping Station*

WILSON AVENUE SYSTEM OF CHICAGO WATER SUPPLY; WATER COMES TO PLANT THROUGH 12-FT. TUNNEL 8 MI. LONG; PLANT HAS MANY FEATURES OF SPECIAL DESIGN. BY JOHN ERICSON, CITY ENGINEER

WITH AN INEXHAUSTIBLE supply of water at its very doors, the City of Chicago, it may seem to the uninitiated, should not have to worry about its water supply, and yet during the thirty odd years that I have been connected with water works construction and management in this city I hardly recall a time when there have not been more or less feverish activities in order to meet the constantly growing demands for additional water.

Various causes have contributed to this situation. The phenomenal growth of this city, annexations of large territories with their inadequate local systems, and the extensive areas to be supplied are some of the contributory causes.

The excessive required per capita pumpage due to an abnormal waste and leakage, and the persistent refusal on the part of the people of Chicago and their elected representatives to adopt a meter system are, however, the principal reasons for the more or less unsatisfactory situation.

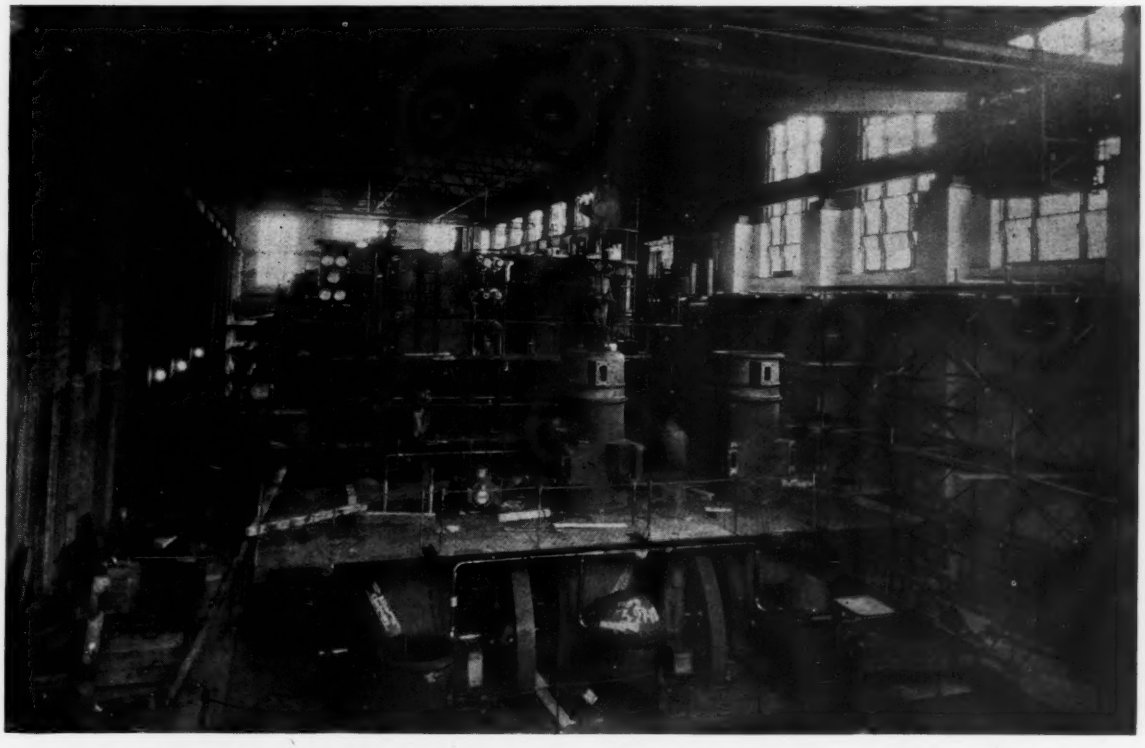


FIG. 6. GENERAL VIEW OF MAIN PUMP ROOM FROM WEST END, SHOWING UNIT BEING ERECTED

A thorough and exhaustive study is now being made of the requirements up to and including the year 1940, and the results of these investigations will be submitted in a future report.

The Wilson Avenue system, which will be briefly reviewed, consists of a tunnel 8 mi. in length, of which

*From a paper read before the Chicago Section of the A. S. M. E.

3 mi. are located under Lake Michigan, and a pumping station at the western terminus of this tunnel, located in Mayfair at Wilson and N. Lamon Avenues.

The Lake View pumping station, located at Montrose Boulevard and the Lake Shore, is supplied by a tunnel, the intake of which is located about 200 ft. south of the new Wilson Avenue tunnel and 2 mi. from shore.

In order to increase the tunnel capacity to this station and to obtain a pure supply, it was planned so to design the new Wilson Avenue tunnel and to connect it to the Old Lake View tunnel and crib that all the water supply to this station would also be taken at the new Wilson Avenue crib, so that the old Lake View crib could be abandoned. The design of the new tunnel, therefore, was based on the following considerations:

It was found that a 12-ft. tunnel would best meet the requirements financially and otherwise and this size was decided upon.

One hundred and fifty million gallons of capacity was decided upon for the Mayfair pumping station, 100 million gallons for the Lake View pumping station and 100 million gallons for future demands.

The actual tunneling was commenced by the recommended day labor method in September, 1914, the shore shaft having been previously sunk.

One of the unusual features in the method of finishing the tunnel was the use of the crushed rock taken from the tunnel in finishing the surfaces of the tunnel. The stone, after blasting, was loaded into small cars which were hauled up an inclined track and, by gravity method, the small pieces of rock were screened out and used with cement in lining the tunnel. This screening and cement mixing was all done in the tunnel and eliminated a vast amount of hauling and hoisting.

Collapsible steel forms were used in finishing the walls of the tunnel and the cement was pressed into position through an 8-in. pipe by means of compressed air. The result was a smooth, almost glazed surface. The design of the forms was such as to permit the passage of tunnel cars during the entire process of lining, making it possible to follow the work of tunneling almost immediately by the finishing process, resulting in great economy of time.

Many and serious have been the obstacles in our way, but the work is finished, and there is no "come back."

The main buildings comprising the Mayfair pumping station consist of the pump room 236 ft. by 60 ft. facing south with an extension at the center 70 ft. by 28 ft. containing the chief engineer's office, locker rooms, etc., and stairway leading to the visitors' gallery.

Adjoining the pump room to the north is the boiler room 209 ft. by 54 ft. with rooms at each end 15 ft. wide for store rooms, wash and locker rooms, etc.

At the north of the boiler room, central with it and separated by a covered driveway 18 ft. in width, is the coal receiving room 72 ft. by 70 ft.

The street grade elevation at the station is +31.5 ft. The elevations of the various floors, etc., are as follows:

Offices and entrance	+33.0 ft.
Main or visitors' gallery in pump room	+13.917 ft.
Pump room basement	— 7.146 ft.
Crane runway in pump room	+52.5 ft.
Center line of high level discharge piping	+ 9.5 ft.
Center line of low level discharge piping	+ 4.0 ft.
Boiler room floor	+28.84 ft.
Boiler room basement	+13.92 ft.
Coal receiving track, present	+36.10 ft.
Coal receiving track, future	+45.8 ft.
Coal receiving room, basement	+ 8.62 ft.

The elevation of the pump room floor, which is 38.65 ft. below the street grade elevation, was determined by the estimated loss of head in the tunnel when delivering the maximum desired quantity of water.

FIG. 1. EQUIPMENT FOR SCREENING IN TUNNEL

FIG. 2. STEEL FORMS ON TRAVELERS WITH 8-IN. CONCRETING PIPE IN OPERATING POSITION

FIG. 3. STEEL FORMS FROM THE REAR, SHOWING PART OF FINISHED WALLS

The Pumping Station

In the 1905 report on future extensions of the Water Supply System, I outlined a proposed tunnel and pumping station in the northern part of the city, and designated it as the Devon Avenue System. The investigations made up to that time were of a more general character, and the location for the pumping station not definitely given.

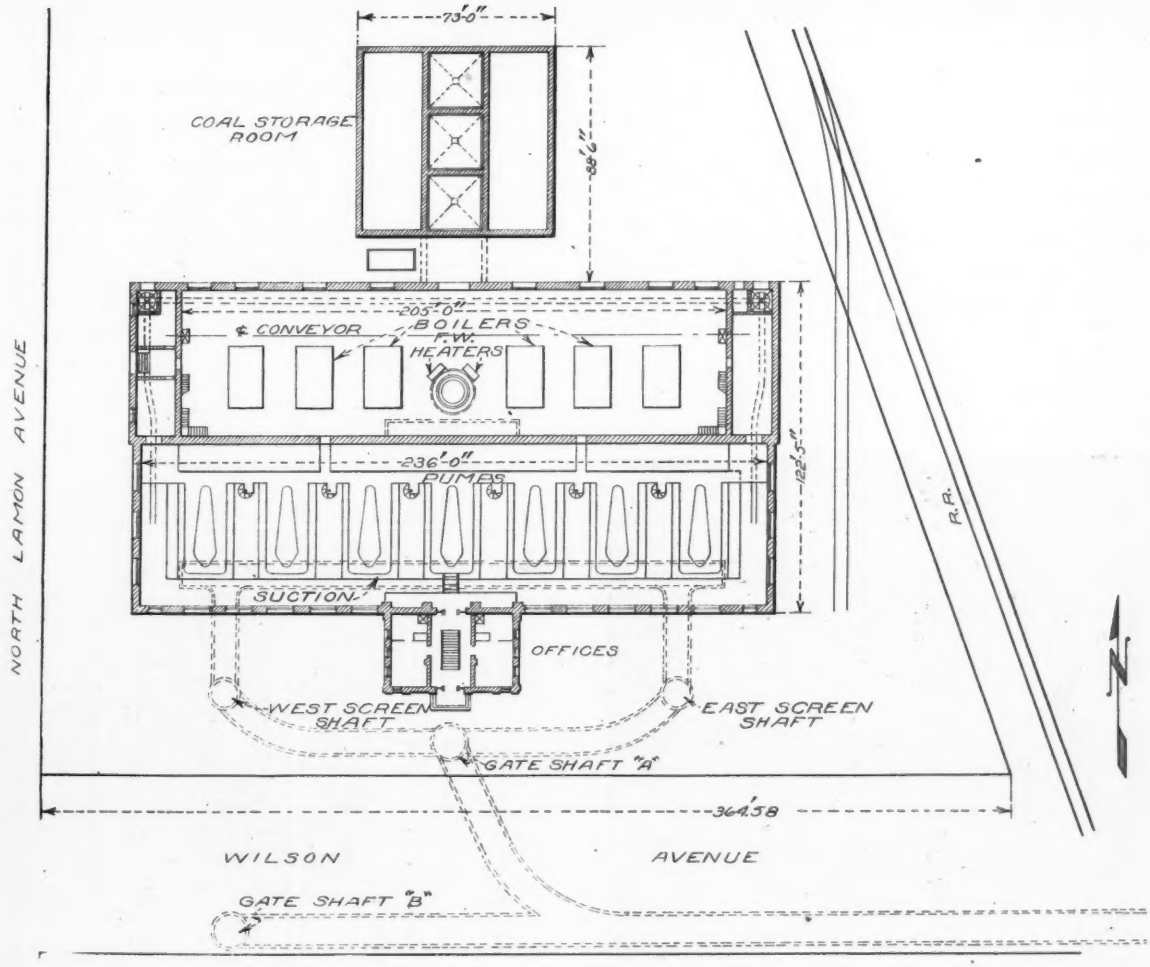


FIG. 4. PLAT OF THE MAYFAIR PUMPING STATION

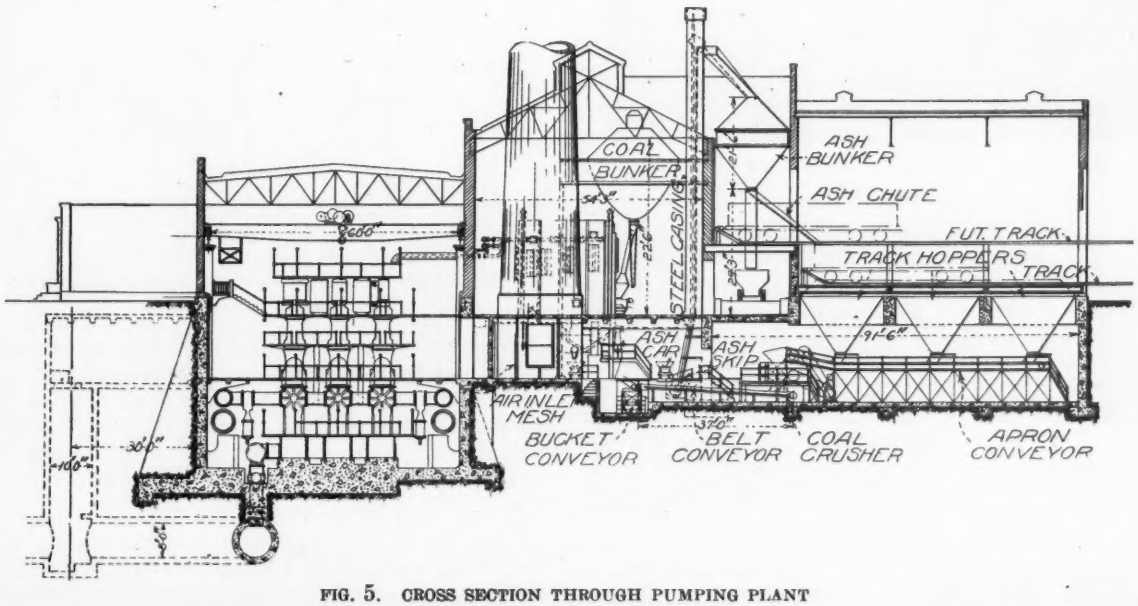


FIG. 5. CROSS SECTION THROUGH PUMPING PLANT

When this subject was later taken up for final consideration, the somewhat changed conditions, and a more detailed study of the situation at the time made a change in the location of the pumping station to a point somewhat further south advisable, and a tract of land at Lamon and Wilson Avenues, with ample railroad facilities, was bought for the purpose. This practically also determined the location of the tunnel, which lies under Wilson Avenue throughout its entire length, east of the station to the Lake Shore, and thence continuous under the lake in a straight line to the crib.

Before the type of pumping units to be selected for the new station was decided upon, a careful analysis of various types was made.

In 1902, when new pumps were to be installed at the Chicago Avenue pumping station, bids were submitted on pumping engines with Riedler mechanically con-

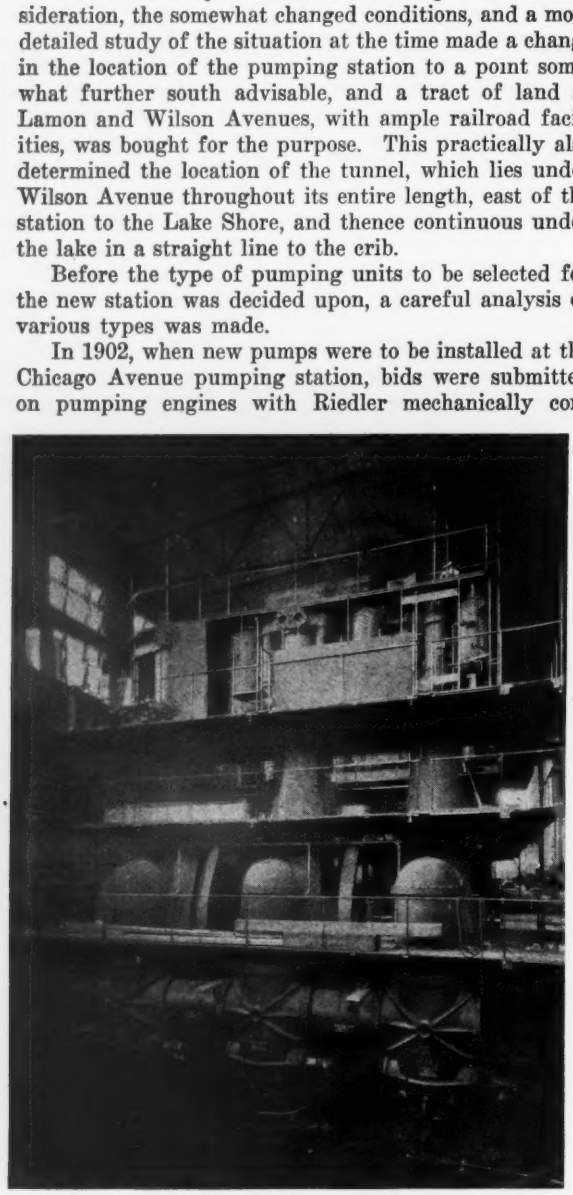


FIG. 7. COMPLETED PUMPING UNIT IN EAST END OF BUILDING

trolled valves, which were many thousands of dollars less than for pumping engines of other types. I had had occasion the year previous to study the performance of this type of pumps in the Hawaiian Islands, and before coming to a conclusion as to my recommendation for award, I further visited some cities in the East where this type was in operation. The result was, that the Riedler type of pumping engines was recommended for the Chicago Avenue station. When pumps for the Lake View station came up for consideration, in view of the satisfactory performance, for many years, of the Chicago Avenue engines, and, at the strong recommendation of Col. Henry A. Allen, then connected with the Bureau of Engineering, it was decided to adopt the same type of pumping engines for that station. The plans for these pumping engines were prepared in the office of the City Engineer, and bids were invited from the various pump manufacturers on these plans. Most attractive bids were received. The pumps were manufactured and installed, and have ever since given good satisfaction.

In view of the satisfactory performance of engines of this type in the other stations mentioned, with plans already prepared, and which required only some modification to fit the Mayfair station, and in view of the very attractive costs in the case of the previous pumping engines of this type, and the uncertainty, in my mind, as to the performance and durability of centrifugal pumping units for water works purposes under Chicago conditions, based on our experience with experimental units

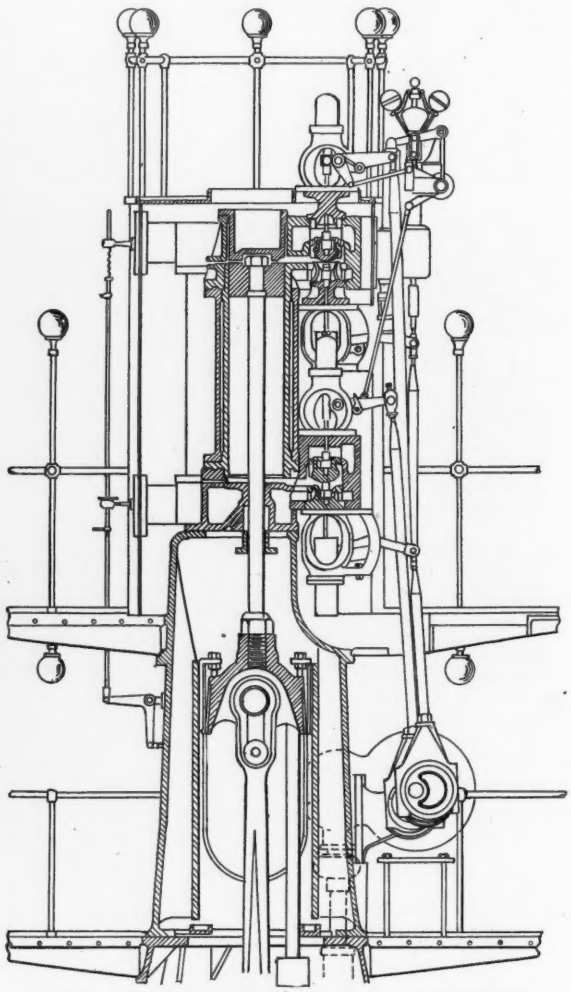


FIG. 8. STEAM END OF PUMPING ENGINE SHOWING VALVE DETAILS

of this type, it was decided to adopt the Lake View type of pumping engines for the new Mayfair station.

The pumping station buildings are all of brick with cut stone trimmings. The interior or the pump room and entrance lobby is cream colored terra cotta; the interior of the boiler room salt glazed brick.

Mechanical Equipment

THE SITE of the pumping station was selected adjacent to the tracks of the Chicago, Milwaukee & St. Paul Railway to afford good switchtrack facilities for the supply of coal and other materials required. The coal track

leaves the main line siding on a curve and enters the coal receiving room in a north and south direction. In the track outside the building is placed a 150-ton railroad track scale.

The coal receiving room has a track length of practically 60 ft. spanning three steel concrete lined track hoppers of 150-ton aggregate capacity at present elevation. At the future elevation at which it is proposed to place the tracks when the main line of the railroad is elevated, additional hopper capacity of 1000 tons will be available. Bins on either side of the track hopper afford additional storage capacity, which could be filled by hand shoveling with portable belt conveyors or unloaders.

Coal is discharged from the track hoppers on to an apron conveyor 30 in. wide, traveling at a speed of 15 ft. per min., which discharges into a four-roll coal crusher of 40 tons per hour capacity. The crusher has 40 tons per hour capacity, and discharged on to an 18-in. belt conveyor, which delivers the coal to the main pivoted-bucket conveyor running at right angles to the belt conveyor and extending the full length of the boiler room above the coal bunkers and below the basement floor.

The coal bunkers, extending nearly the full length of the boiler room, are steel, concrete lined, elliptical bottom type, having an aggregate capacity of 1000 tons, the entire top of which is closed by a sheet steel dust cover. Two spouts are provided in the bottom of the bunkers opposite each boiler and two additional spouts near the center in the open space between boilers are provided for connection to the lower run of the pivoted-bucket con-

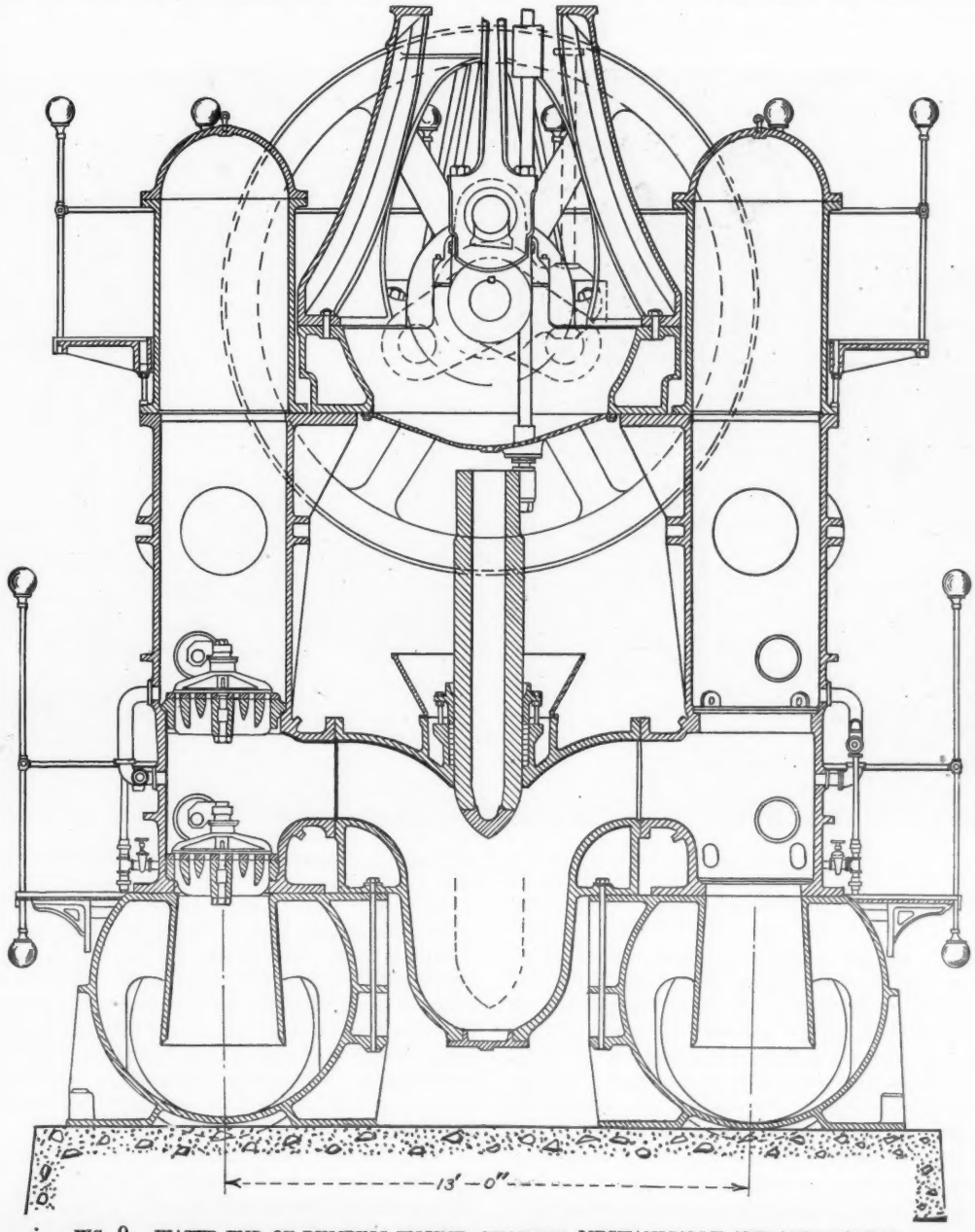


FIG. 9. WATER END OF PUMPING ENGINE, SHOWING MECHANICALLY OPERATED VALVES

veyor, so that the coal in this space can be transferred to any other part of the bunker as needed.

All parts of the coal conveying machinery, as well as the coal crusher, are driven by vertical steam engines.

The steam generating equipment consists of six 500-hp. Edge Moor horizontal water tube boilers provided with six-retort Taylor underfeed stokers. Each boiler contains 237 4-in. tubes 20 ft. long spaced 34 tubes wide and 7 tubes high connected to steel box headers at front and rear. The total heating surface of each boiler is 5160 sq. ft. The bottom of front header is placed 10 ft. above the boiler room floor, giving a combustion chamber of liberal size as required to burn the high volatile Illinois and Indiana Coal.

Above the tubes and below the two 36-in. diameter steam drums are placed the three 2-in. elements comprising a Foster superheater, each element containing 24 tubes, the total rated superheating surface being 1000 sq. ft.

Baffles are arranged to give four passes of the furnace gases across the tubes, the gases leaving the bottom of the last pass enter a horizontal breeching located beneath the main boiler room floor. The six boilers are divided into two groups of three each with the radial brick chimney located in the space between the two groups. A separate breeching connects each group of boilers with the chimney, entering near the base on opposite sides.

The boiler baffles contain the Edge Moor steam jet soot blower for blowing soot from the boiler tubes. A separate soot blower designed by the city has been provided for the superheater elements.

The six-retort Taylor stoker covers the full boiler furnace width of 10 ft. 10 in. and contains an active grate area of 107 sq. ft., including extension grates. The dumping plates for ash and clinker are power operated by means of steam cylinders and connections.

Air for combustion is supplied each unit by a 140-in. special steel plate fan driven by a 6 by 7-in. vertical direct connected steam engine, which also furnishes the power for driving the stoker. Each fan is capable of supplying air at pressures up to 4½ in. of water, although normally but half that pressure will be needed.

The boiler settings are constructed of a 9-in. fire brick lining, 8 in. of sewer brick, 2 in. of asbestos cement felting; the whole inclosed in a casing made of No. 10 gage sheet steel. Door openings are provided for inspection and cleaning.

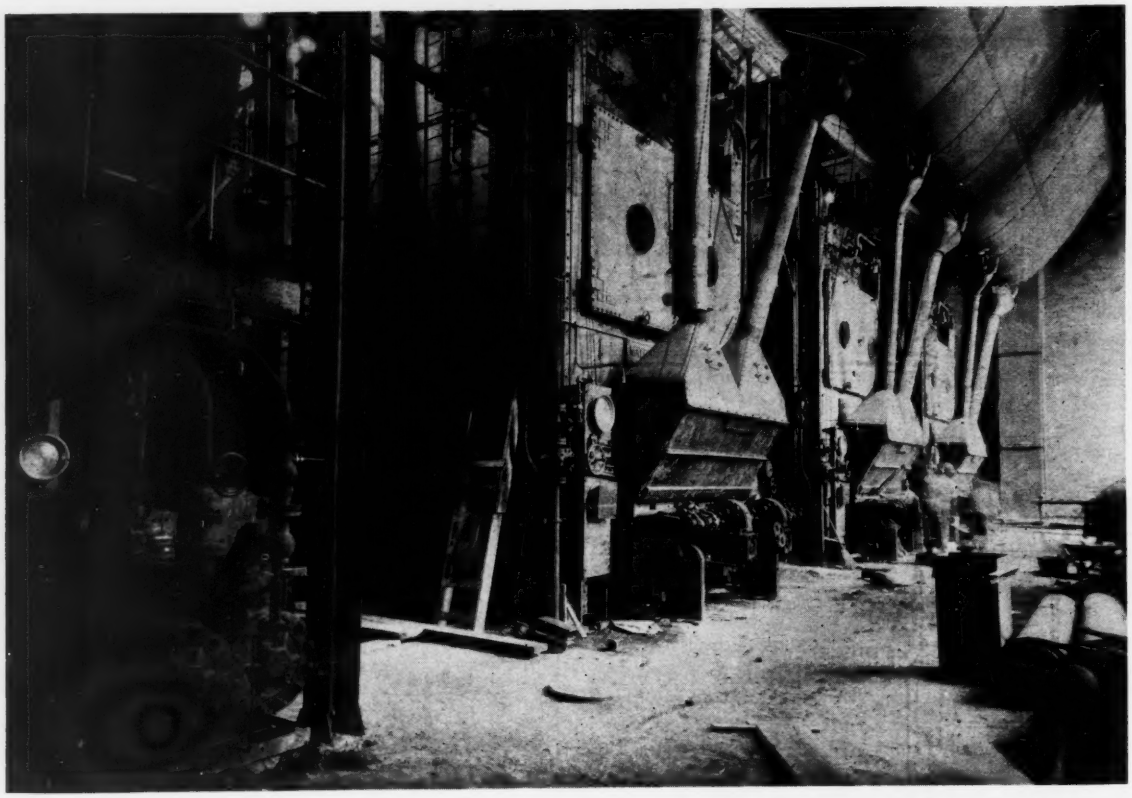


FIG. 10. VIEW IN BOILER ROOM LOOKING WEST FROM THE CENTER; FEED PUMPS WITH HEATER ABOVE SHOWN AT LEFT

In addition to the usual boiler fittings installed, each boiler is equipped with indicating, integrating and recording steam flow meters for determining the boiler evaporation, differential draft gages for indicating the draft in any part of the gas passage up to the breeching, recording thermometers to record the temperature of the gases leaving the boiler and the temperature of the superheated steam leaving the superheater, also a gage for indicating the pressure of air supplied to the stoker wind-box.

In order that these instruments may be readily accessible for the boiler room attendants, they are mounted on two small gage boards attached to the front of each boiler setting.

Each steam generating unit is guaranteed to operate at normal rating, generating steam of 190 lb. per square inch gage pressure and of 200 deg. F. superheat with a combined boiler and stoker efficiency of 75 per cent. Each unit is designed to operate continuously at 50 per cent over normal rating.

Natural draft for taking away the products of combustion is provided by a radial brick chimney previously mentioned, which is 184 ft. in height above the boiler room floor and 9 ft. internal diameter at the top. The outside diameter at the base is 19 ft. 3 in., tapering to a minimum diameter of 10 ft. 8 in. at the top.

The feed water supply is made up from the hot water returns from the main pumping engines, the heating system when in operation, and the exhaust steam from the various steam driven auxiliaries which is condensed in the open feed-water heaters by the cold water admitted from the city mains to make up the deficiency.

Two feed-water heaters of 2500 boiler horsepower capacity and 253 cu. ft. total contents are located near the center of the boiler room upon an elevated platform. The feed water, which will be heated as near to 212 deg. F. as the quantity of exhaust steam makes possible, flows from the feed-water heaters through one of two V-notch meters by which the quantity of water passing to the feed pumps below is measured and recorded.

Three feed pumps are provided, but two pumps will ordinarily supply the entire station. The pumps are horizontal, duplex, direct-acting steam pumps 14 by 8½ by 12 in., with outside center packed plungers, bronze fitted.

The speed of the pumps is automatically controlled by an excess pressure pump governor operating in accordance with the steam pressure carried in the boilers. The water level in each boiler is automatically controlled by a feed-water regulator of the closed steam generator type attached near and in connection with the water column of each boiler.

Ashes accumulating in the concrete ash pit constructed beneath each boiler are moved by side-dumping ash cars to one of two ash skips, which automatically hoist and discharge the ashes into an elevated ash bunker located over the driveway between the boiler room and the coal receiving room. This bunker will hold two and one-half days' accumulation of ashes, which can be discharged by spouts into auto trucks or wagons or into railroad cars on the coal receiving track. A 25-ton auto truck scale is provided in the driveway above mentioned.

An electric freight elevator is installed in the east end of the boiler room building by which supplies can be delivered to the basement or to the boiler room floor from the street grade level.

Pumping Engines

The main pumping engines are vertical, triple-expansion engines with water ends containing three single acting plungers. The pump room has been designed for seven pumping units, but only five have been contracted for. These five have identical steam ends, but different water ends, three pumps being designed for regular supply or low-level service of 140 ft. head, while two pumps will supply a correspondingly smaller quantity at the high level service of 200-ft. head intended to supply the sections of the city to the north and west of the station and at higher elevations.

The principal dimensions of the driving engines are: High-pressure cylinder 15 in. diameter, intermediate cylinder 29 in. diameter, low-pressure cylinder 50 in. diameter, stroke 48 in.

The high-pressure cylinder has double-beat poppet valves suited for use with highly superheated steam. The intermediate and low-pressure valves are of the Corliss type.

The low-level pumps have three plungers 24⅛ in. in diameter and 48 in. stroke. For each plunger there are two pump bodies, each containing one suction and one discharge valve of the Riedler mechanically controlled type, which permit a higher plunger speed than any other type of valve used on reciprocating pumps.

The feature of the Riedler valve is that it is positively closed by levers at the end of the stroke, but is free to open according to the movement of the plunger and the pressure caused thereby, which is a negative pressure in the case of the suction valve opening on the suction stroke and a positive pressure in the case of the discharge valve opening on the discharge stroke. The valve, which is 40 in. in diameter, is really a multiple valve consisting of several concentric circular ports and covers.

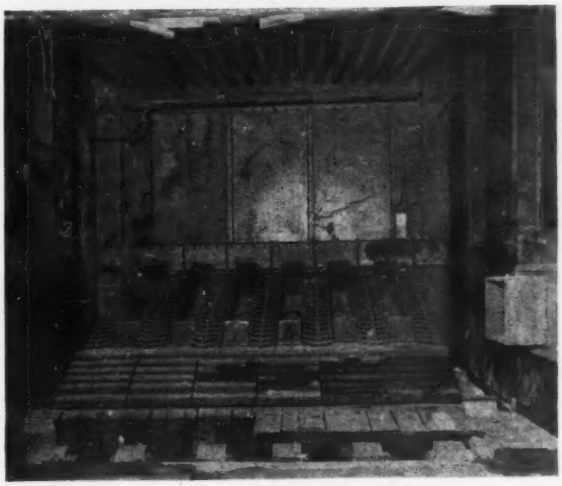


FIG. 11. INTERIOR OF BOILER NO. 3 DURING ERECTION

These pumps contain six suction and six discharge valves, whereas a pump of equivalent capacity using automatic valves of small diameter would have hundreds of them.

These low level pumps have a rated capacity of 25,000,000 gal. each per 24 hr. against the normal head of 140 ft. when operating at 62 r.p.m., or a plunger speed of 496 ft. p.m.

The high level pumps have three single-acting plungers 20⅛ in. diameter and 48 in. stroke. They have six Riedler suction valves and six Riedler discharge valves about 32 in. in diameter.

These high level pumps have a rated capacity of 17,500,000 gal. each per 24 hr. against a normal head of 200 ft. when operating at the same speed, 62 r.p.m. The pumps are all capable of being operated at 73 r.p.m., corresponding to a plunger speed of 584 ft. p. m., and delivering water against maximum heads of 160 ft. and 231 ft., respectively. All the pumps have two 36-in.

diameter suction nozzles. The high level pumps have two discharge nozzles 24 in. in diameter.

The steam cylinders are all steam jacketed, the high-pressure cylinders with high-pressure steam only, the intermediate cylinders with either high-pressure steam or steam from the first receiver which is between the high and intermediate-pressure cylinders; the low-pressure cylinder jacket can be supplied with steam from either the first or second receiver.

Reheating coils were omitted from the first and second receivers, removing a possible source of trouble and of doubtful improvement of steam economy.

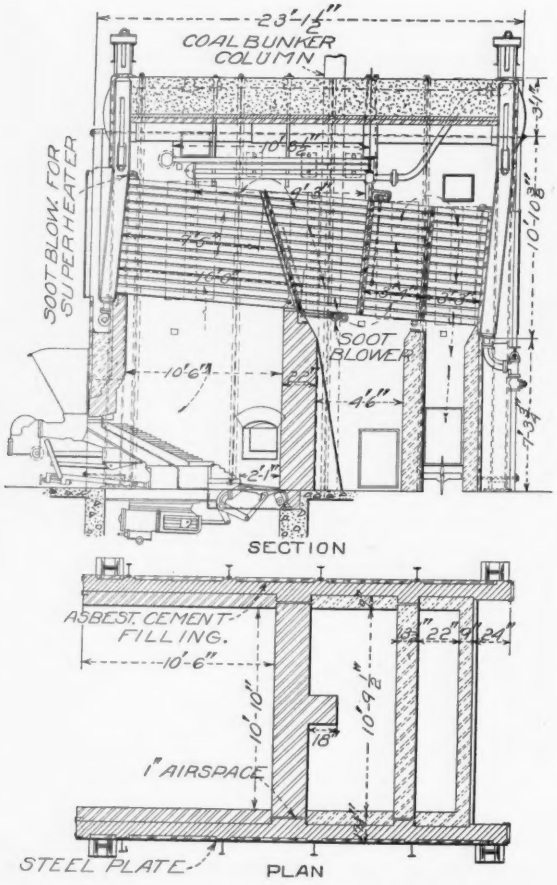


FIG. 12. ELEVATION AND PLAN OF BOILER, SHOWING ARRANGEMENT OF BAFFLES AND FURNACE DIMENSIONS

The exhaust steam from the low-pressure cylinder is condensed in a water works type of condenser through which all of the water pumped by the unit passes during the suction strokes. Each condenser contains 1200 sq. ft. of cooling surface made up of 600 1⅛-in. diameter brass tubes 7 ft. long tinned inside and out.

The water and vapor contained in the exhaust steam are removed from the condenser by an independent vertical steam driven crank and flywheel air pump of the piston plunger type with plunger 22 in. in diameter and steam cylinder 9 in. in diameter, both of 14-in. stroke. The discharge from the air pump is led to a cast-iron hot well from which the vapor is allowed to escape, while the condensed steam or water is handled by a hot well pump with plunger 4 in. in diameter and with a variable stroke attached to and driven by the air pump, which pumps the water up to the feed-water heaters in the boiler room.

The water pumped by the low-level pumps is passed through 54-in. discharge headers of which there are two. The water pumped by the high-level pumps is passed through 42-in. diameter headers, also in duplicate.

The gate valves on both the suction and delivery sides of the pumps are hydraulically operated and capable of operating with a water pressure in the power cylinder of 30 lb. per sq. in.

All drips and leakage from the pumping engines, boiler blowoff, discharge from oil separators, etc., are led to a 6-ft. diameter cast-iron sump basin, the bottom of which is 10 ft. 10 in. below the pump room floor, from which the accumulation is pumped by a vertical turbine-driven centrifugal sump pump having a rated capacity of 200 gal. per min. against a head of 50 ft. discharge into the city sewer system.

A horizontal steam driven air compressor with cross compound steam cylinders 8 by 14 by 12 in. and duplex air cylinders 10 by 12 in., having a capacity of 180 cu. ft. of free air per minute, is located near the east end of the pump room, and supplies compressed air principally for charging the air chambers of the main pumping engines.

The lubrication of the bearings of the pumping engines is accomplished through a complete independent oiling system for each unit, consisting of an overhead gravity supply tank connected by means of nickel-plated pipe and fittings to sight feed oilers, telescopic, trombone and other oilers.

The used oil is collected and conveyed through suitable piping to an oil filter and separator, in which dirt and water are separated from the oil which is then pumped back to the gravity reservoir for use over again. The oil filters have a filtering capacity of 200 gal. per hour sufficient to allow slow and effective filtering.

Steam cylinders and valves are lubricated by mechanical lubricators whose motion is obtained from conveniently located moving parts of the pumping engines.

Oil received at the station in barrels is run into 500-gal. storage reservoirs, one for machine oil and one for cylinder oil. Oil to fill or replenish the machine oil supply used in the gravity system or for filling the mechanical lubricators is forced from the reservoirs by compressed air. A small individual oiling system is provided for the air compressor, and another to care for the three boiler feed pumps.

All large high-pressure steam piping is made up with joints of the Van Stone type. Boiler blowoff and feed lines are extra heavy wrought iron. All valves in lines handling high-pressure steam are gate valves of the straight way. Venturi type with bodies of cast steel and monel metal discs, seat rings and spindles.

The heating system of the station is supplied by the exhaust steam from the steam-driven auxiliaries, which can be supplemented with steam from the main pumping engine receivers if desired or by live steam.

It is of the wet vacuum type with returns handled by a single steam-driven, direct-acting vacuum pumps and delivered to the feed water heaters in the boiler room.

The cost of Mayfair pumping station when completed will be about as follows:

Foundations	$ 388,000
Buildings	334,500
Pumps and auxiliaries, including discharge piping in station	465,000
Boilers	135,000
Piping	95,000
Coal conveying machinery	37,000
Chimney	10,500
Tracks and scales	8,000
Improvement of grounds	14,000
Miscellaneous small contracts	27,500
Engineering	55,500
Total for station	$1,570,000
Total for tunnel	3,856,000
Grand total	$5,416,000

Hot Water Service

METHOD OF CALCULATING HEATING SURFACE REQUIRED. BY M. W. EHRLICH

THERE IS no question but that it pays to heat the feed water before it is sent into the boilers. Where exhaust steam from engines and pumps is available, the economy is more marked; 8 to 13 per cent may be expected. How the heating of the feed water is accomplished is ordinarily understood; the steam in condensing gives up its heat, which is transmitted to the water, in that way raising the temperature. The amount of heating surface required for this work and the quantity of live or exhaust steam needed are usually more or less perplexing items.

The heating of water in closed tanks by means of steam may be accomplished either by passing the water through tubes or coils surrounded by steam or by passing the steam through coils surrounded by the water. As a rule, when the steam after doing its useful work is allowed to waste to a drain or to the atmosphere, a water-tube heater is used; while, if the steam is to be returned to the system the steam coil type is preferable.

Taking practical installations as they are found under actual conditions, this sums down to steam-coil heaters for live steam supply and water-tube heaters for exhaust steam service. The reason for this may be found in the fact that if the exhaust steam would be passed through small size tubing or pipe coils, considerable back pressure would be created and interfere with economic operation of the engines in the plant. A simple arrangement of a feed-water heater which is typical of installations using exhaust steam for pre-heating boiler water, is shown in Fig. 1.

For heating water for domestic service a steam coil may be provided in the storage tank, as shown in Fig. 2. Such heaters, known as "hot water generators," usually use live steam. A good many others, however, use exhaust steam, with the water passing through the tubes. There are many styles of both types of heaters suitable for any kind of commercial, industrial or domestic hot water service.

An ingenious arrangement of a closed tank type vertical coil heater is shown in Fig. 3. This has two sets of spiral coils within the tank, the water passing through the coils while the exhaust steam surrounds them. Each coil is continuous and independent of the other and may be made of brass or copper. This heater is therefore capable of handling two different services at the same time.

Cold water for boiler feed purposes enters the coil at one side near the bottom, while cold water for the other building service enters the second coil at the opposite side. The hot water outlets are near the top as shown.

In the many different styles and types of such hot water generators, the underlying principle is the same regardless of whether it is the water or the steam that passes through the tubes of the heater. There is little practical difference as regards bent, curved, corrugated or even special shapes of tubes, so far as net heating value for a total given surface is concerned. The striking fact in heating water through submerged coils is that each sq. ft. of useful heating surface will liberate 50 to over 100 times as much heat as will the same coil surface in still air. The range in heat transmission depends upon the materials of which the coils are made. The value of this transmission varies, however, with the steam pressure, water temperature and velocity of flow.

Experiments and practice show that under average operating conditions the useful heat transmission

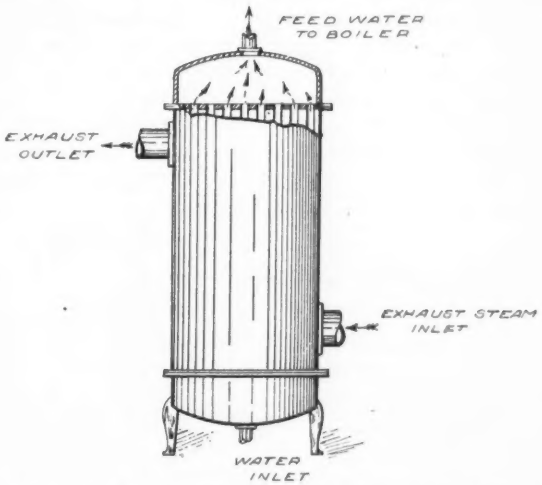


FIG. 1. A TYPICAL WATER TUBE FEED-WATER HEATER

through an iron pipe coil would be 100 B.t.u. per sq. ft. per hr. for each degree of mean temperature difference between the steam and water. Under the same conditions, brass pipe would transmit 200 B.t.u. and copper coils 240 B.t.u. Therefore, to state simply that so many sq. ft. of heating surface are required for a given capacity is misleading as well as erroneous, because the conditions of service and the material of the coil are not stated. From the above figures alone it can be seen that

2 sq. ft. of iron pipe would be required under a set condition to give the same result as 1 sq. ft. of brass pipe.

In determining the heating surface of a steam-coil or water-tube heater for hot water storage tanks, feed-water heaters, instantaneous heaters or for other similar hot water service the following factors must be taken into consideration: Temperature of incoming cold water, temperature of outgoing hot water, number of lb. or gal. to be heated in an hour, the steam pressure available and the material of the coil which is to form the heating element.

The water supply taken from the mains may average about 50 deg. F., in temperature; while in cold winter weather it may at times be as low as 40 deg. F. For boiler feed service, this supply should be heated to as near 212 deg. F. as possible; practically this, however, will average from 200 to 208 deg. F. For domestic or industrial service the temperature may vary from 80 to 200 deg. F., according to the nature of the work or the process of manufacture. The steam supply for such heating may be from any source and may be either live or exhaust, its pressure determining the available temperature.

It is known that steam at atmospheric pressure has a temperature of 212 deg. F.; at 2 lb. gage pressure, about 218 deg. F.; at 6 lb. gage, about 230 deg. F.; at 10 lb., 239 deg. F.; at 20 lb., 259 deg. F.; and at 30 lb. gage, about 274 deg. F. Therefore, when the pressure of the available steam supply is known, its corresponding temperature is also known.

With these factors known, consider a 300-hp. boiler plant that is to be provided with a feed-water heater. The engines deliver a sufficient quantity of exhaust steam to supply all needs as well as the feed-water heater. While in winter this exhaust will be at a back pressure of 5 lb., it will be discharged at atmospheric pressure during the summer months. As the feed heater must be proportioned for the most severe conditions, the lower pressure will be used in the computations. The cold water available for this purpose is taken from a driven well and has a minimum temperature of 40 deg. F.

Three hundred horsepower in boiler capacity steaming at one time will require at least 30 lb. of water per hp. hr., or a total of 9000 lb. of water during one hr. As the final temperature of the feed water is desired to be 212 deg. F. and the cold water supply is 40 deg. F., a rise in temperature of 212 minus 40, or 172 deg. F. is necessary. It is further known that raising the temperature of 1 lb. of water through 1 deg. F., requires an expenditure of 1 B.t.u. Then, if 9000 lb. of water have to be raised 172 deg., a heat value of 9000 times 172, or 1,548,000 B.t.u. is required.

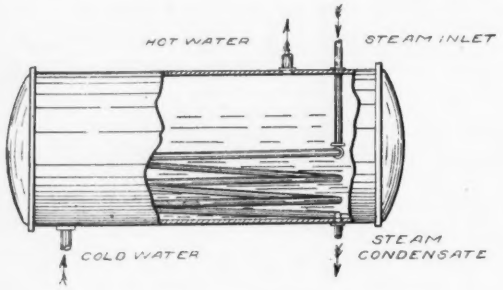


FIG. 2. STEAM COIL STORAGE TANK HEATER

The next step is to determine the mean temperature difference between the steam and water so as to have a basis for arriving at the required heating surface. By adding the cold water temperature to the hot water temperature and dividing the sum by 2, we obtain the average temperature. This, subtracted from the temperature of the steam supply, gives the mean temperature difference between the steam and water.

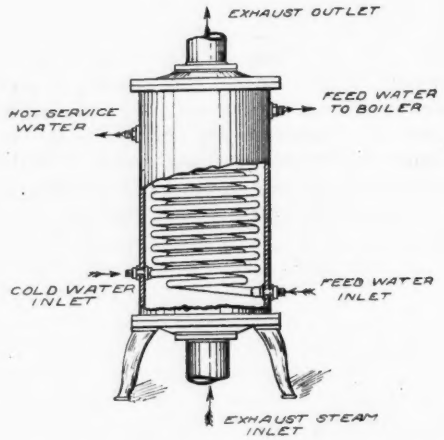


FIG. 3. CLOSED TANK TYPE VERTICAL COIL HEATER

As the cold feed water is at 40 deg. F. and the hot water to the boilers is 212 deg. F., the average temperature is 40 plus 212, divided by 2, or 126 deg. F. Steam at atmospheric pressure has a temperature of 212 deg. F. Then 212 minus 126, or 86 deg. F., which is the mean temperature difference. If iron coils or tubing are to be used as the heating element in the heater, each square foot will transmit, as previously shown, 100 B.t.u. for 1 deg. F. mean temperature difference. Therefore, for 86 deg. F. as required, the transmission will be 86 times 100, or 8600 B.t.u. per sq. ft. per hr. Knowing that the service under consideration requires 1,548,000 B.t.u., it is only necessary to divide this value by the transmission figure. Then 1,548,000 divided by 8600, or 180 sq. ft., which is the iron pipe heating surface required for this feed-water heater to serve a 300-hp. boiler installation.

After this figure is determined, then it is a simple matter to compute the number, size and length of coil or tubing necessary to make up the total heating surfaces so as to fit the heater.

This method of computing the heating surface required for steam-coil or water-tube heaters using steam as the heating medium, may be applied equally well, for accurate results, to any and every similar problem under all conditions of temperatures and service.

The main factors as previously given may be written in simple expressions as follows:

R or rise in water temperature $= T_h - T_c$

A or average water temperature $= (T_c + T_h) \div 2$

M or mean temperature difference $= t_s - A$

T_h is the temperature of the hot water; T_c is the temperature of the cold water; t_s is the temperature of the steam. With this established, the size of coil re-

quired for any hot water service may be found by the following formula:

$$H.S. = \frac{R \times w}{M \times f}$$

in which H.S. is the square feet of required heating surface; w is the weight of water in pounds per hour; f is a factor which is equal to 100 for iron, 200 for brass and 240 for copper.

To apply this rule, consider a small laundry installation employing five washers. These and the auxiliary equipment each use about 200 gal. hot water in an hour. This water is required at 180 deg. F., while the cold water comes in at 50 deg. F. Live steam at 10 lb. pressure with a temperature of 239 deg. is available for this work and a steam-coil heater of the horizontal type is to be provided.

According to the rules given:

$R = 180 - 50 = 130$ deg. F.
$A = (50 + 180) \div 2 = 115$ deg. F.
$M = 239 - 115 = 124$ deg. F.

The five washers and equipment using 200 gal. each means a total of 1000 gal. an hour and at 8.33 lb. to the gallon, gives an hourly demand of 8330 lb. Assuming that a brass steam-coil has been decided upon, the value for f, as given, is 200. Then the heating surface required is found to be, according to the formula:

$$H.S. = \frac{130 \times 8330}{124 \times 200} = 43.7 \text{ sq. ft.}$$

If this heater were to be equipped with a copper coil instead of brass, the heating surface required would be but 35 sq. ft.

Suppose that the brass coil for this heater were to be made of 1½-in. pipe which exposes about ½ sq. ft. of surface for each foot of length. As a total of 43.7 sq. ft. of heating surface are required, it is clear that 87.4 lineal feet of this pipe would have to be used. Suppose that this brass coil, if made 5½ ft. long, would just fit into the tank heater. For this condition, then, 16 tubes would be required or a similar number of turns for a trombone coil, each 5½ ft. long.

For a practical approximation of the hourly quantity of steam required it is only necessary to divide the total British thermal unit requirements by 1000. For the feed-water heater first considered the steam rate would then be 1,548,000 divided by 1000, or 1548 lb. of steam an hour. Then again, for the laundry heater considered above, the heat requirement is equal to 130 times 8330, or 1,082,900 B.t.u. Dividing this by 1000 indicates that 1083 lb. of steam would have to be supplied hourly. It is interesting to note that for open feed-water heaters, or for heating water in open tanks or vats by admitting steam and allowing it to condense and mix with the water, the same considerations apply. It is necessary only to know the amount of water to be heated in an hour as well as the temperature rise. The number of British thermal units thus found, when divided by 1000, will give a close approximation of the hourly quantity of steam that has to be supplied to heat the water.

Numerous examples could be worked out in the same way, either for coil surface or steam requirements; however, the requirements for any conditions may easily be calculated by the simple method outlined.

Oil Engines---I

THEIR PRINCIPLE OF OPERATION, CHARACTERISTICS AND EFFICIENCIES; FUELS USED

ALL internal combustion engines, that is those in which the piston is actuated by the expansion of gases formed within the cylinder, belong to one of two general types, those in which a mixture of air and fuel is drawn into the cylinder on the suction stroke and compressed on the return stroke, and those in which air alone is drawn into the cylinder on the suction stroke and fuel oil sprayed into the combustion chamber at the end of compression. The former is generally known as the "gas" engine and the latter as the "oil" engine, although many manufacturers erroneously apply the term "oil" to those engines which in reality belong to the gas engine class.

Whether engines are of the gas or the oil operated type, the underlying principles of operation are similar except as to the methods of fuel introduction and its ignition. One of two cycles of events is employed, namely, the two-stroke cycle or the four-stroke cycle; while the former may be used to advantage in large slow speed engines, the four-stroke-cycle engine, due to its simplicity, low cost of construction and the high rotative speeds which may be employed, has proved the more desirable, especially for stationary service. In explaining these two cycles, we will consider them first, for the sake of simplicity and convenience, in connection with the gas engine.

Shown in Fig. 1 is a section of an elementary engine with its piston, cylinder and inlet and exhaust valves, and an ideal diagram of events as they occur in a four-

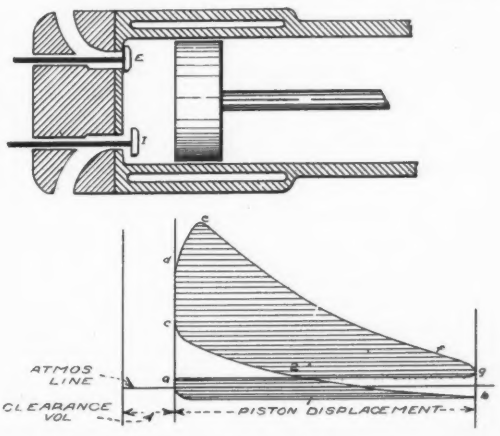
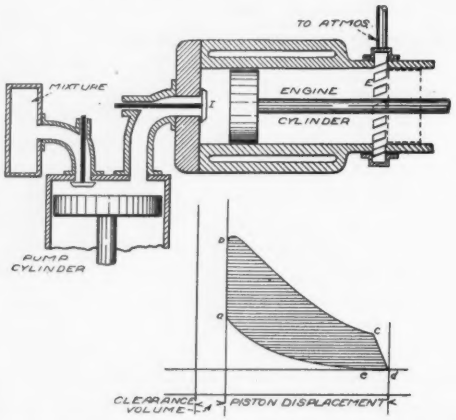


FIG. 1. SECTION THROUGH TYPICAL FOUR-STROKE CYCLE ENGINE AND DIAGRAM OF EVENTS

stroke cycle machine. As the piston moves forward from the position indicated, inlet valve *I* is caused to open and a mixture of air and fuel is drawn into the

cylinder at a pressure somewhat less than atmospheric, this being represented by line 1. On the following return stroke, inlet valve *I* closes, the charge is compressed along line *b c* after which ignition occurs and combustion line *c e* is produced. The gases now expand to



SECTION THROUGH TYPICAL TWO-STROKE CYCLE ENGINE AND DIAGRAM OF EVENTS

point *f*, which is about 85 to 90 per cent of the stroke, when the exhaust valve starts to open for the expulsion of the spent gases; this continues throughout the following stroke and after point *a* has again been reached, the cycle is repeated. It is thus seen that every fourth stroke is a power stroke.

exhaust valve. A separate pump cylinder is provided, although in many engines of the two-stroke cycle type, especially the smaller sizes, a sealed crank case in communication with the power cylinder is utilized as a pump cylinder, the pressure on the outstroke of the piston being raised to about 6 to 8 lb. above that of the atmosphere.

With the inlet valve *I* closed, the cylinder filled with a fresh mixture of air and fuel and the piston in such a position as to be just covering ports *E*, movement of the piston towards the left causes the charge to be compressed by line *e a*; ignition then occurs producing line *a b* with the resulting expansion line *b c*. When the piston again uncovers ports *E*, there is a considerable drop in pressure as may be noted by line *c d*. At this point the pump piston moving upward, forces a fresh charge, taken from the mixture chamber, through inlet valve *I* into the engine cylinder and in doing so clears this cylinder of the remaining spent gases by forcing them out into the atmosphere through exhaust ports *E*. By this time the engine piston will have moved along its return stroke so as to cover ports *E* and the cycle is repeated.

One of the disadvantages of the two-stroke cycle engine is the practically simultaneous induction of fresh charge and expulsion of spent gases, causing, according to many authorities, a loss of as much as 20 per cent of the power; this is due to the impossibility of having the exhaust valve open long enough to get the exhaust gases out of the cylinder and still have it closed in time to prevent some of the new charge blowing through.

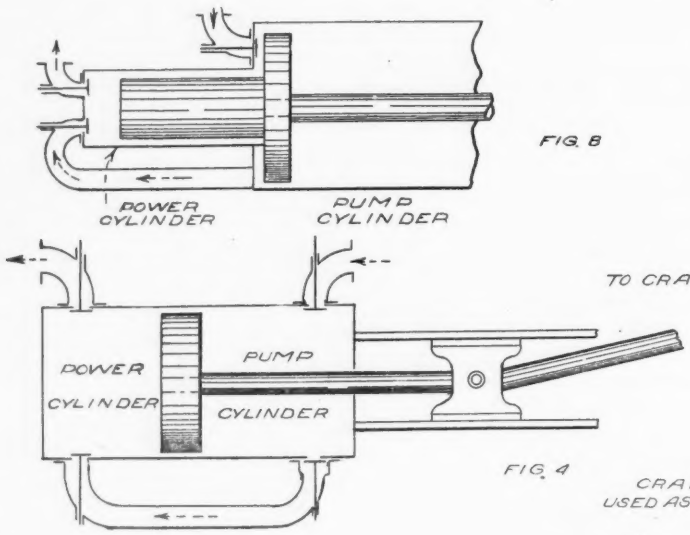


FIG. 4

FIG. 8

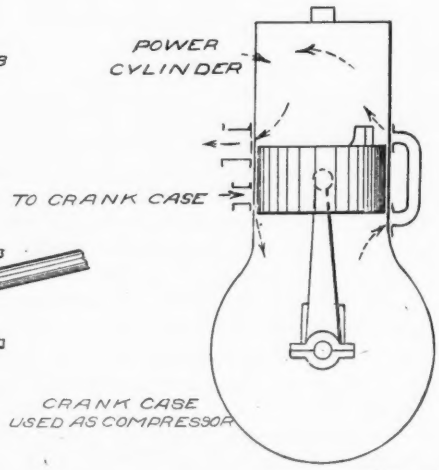


FIG. 5

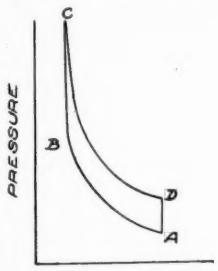
FIG. 3. TWO-STROKE CYCLE ENGINE EQUIPPED WITH AUXILIARY PUMP CYLINDER
FIG. 4. TWO-STROKE CYCLE ENGINE WITH COMBINED POWER AND PUMP CYLINDERS
FIG. 5. TWO-STROKE CYCLE ENGINE UTILIZNG CRANK CASE AS COMPRESSOR

A section of a two-stroke cycle engine and its diagram of events is illustrated in Fig. 2. This engine as shown, instead of being fitted with two valves at the head end, has but an inlet valve *I* at this point, and for the expulsion of the spent gases has a ring of ports *E* cut through the walls at such a point that the piston, by uncovering them near the end of its stroke, acts as an

Some of the various means employed to handle the gases are shown in Figs. 3, 4 and 5, that indicated by the last being the most commonly employed arrangement in connection with the smaller sizes of engines.

Comparing the two and four-stroke cycle of operation, Hirschfelt and Ulbricht in their text entitled Gas Power, state that on a basis of power obtained from a

given size of cylinder, the former would appear preferable. In this type a complete cycle is obtained every revolution, whereas it requires two revolutions with the other method to complete a cycle and produce the same amount of power in the same sized cylinder. This would indicate that a two-stroke cycle engine should give twice the power of a four-stroke cycle engine, with the same



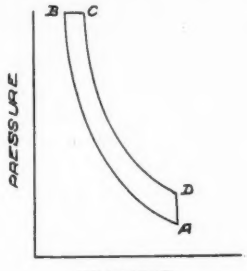


FIG. 6. OTTO CYCLE DIAGRAM
FIG. 7. DIESEL CYCLE DIAGRAM

piston displacement and running at a like speed. Practically, however, such is not the case and the power actually obtained varies from about 1.3 to 1.7 of that obtained from a similar four-stroke cycle engine. This is due to a number of causes, but principally to the difficulty of obtaining perfect scavenging and a pure charge.

Thermodynamic Cycles

In addition to the two and four-stroke cycles of operation, practically all commercial types of internal combustion engines of today operate upon one of two thermodynamic cycles, the Otto or the Diesel. These are represented graphically in Figs. 6 and 7 respectively. In the Otto cycle there is compression from *A* to *B;* ignition and burning at constant volume from *B* to *C*; expansion from *C* to *D*; and rejection of heat to the exhaust at constant volume from *D* to *A*. In the Diesel engine there is a corresponding compression from *A* to *B*, but the burning, instead of at constant volume as in the case of

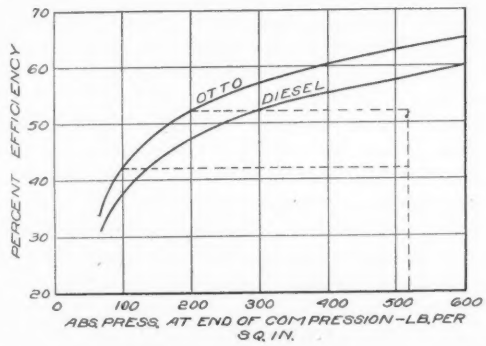


FIG. 8. COMPARISON OF EFFICIENCIES OF OTTO AND DIESEL ENGINES

the Otto cycle, is accomplished at constant pressure from *B* to *C*; expansion occurs along *CD* and exhaust at constant volume along *DA*. In the former there is an explosion while the volume remains constant, thus increasing the pressure and temperature; in the Diesel cycle there is burning at constant pressure, while the volume and temperature increase.

Discussing the relative efficiencies of Otto and Diesel cycles, Adams in his paper on the Diesel Engine and Application (Trans. A. S. M. E., Vol. 37) presents the curves shown in Fig. 8, which indicate that with corresponding pressures at the end of the compression the Diesel engine has a lower thermal efficiency. He then goes on to explain that this is offset by the fact that in the Otto engine the limit of compression pressures is 80 to 200 lb. per square inch, while in the Diesel engine the compression may be carried as high as desired. The reasons for this are that in the Otto engine the fuel is compressed with the air, and preignition will take place if the compression is carried too high, due to increase of temperature with increase of pressure. In the Diesel engine, air only is compressed and the temperature may rise as high as desired without danger of preignition.

Due to these characteristics, the Diesel is capable of reaching the higher degree of thermal efficiency, and on account of the finely divided state in which the fuel is introduced into the cylinder of the Diesel engine, combustion is more complete than in the Otto engine. With the Diesel cycle the maximum degree of thermal efficiency possible of attainment is 57 per cent, while with the Otto cycle it is 52 per cent.

Winning the War

By Jos. W. Hays

ALL of the nations at war with Germany are short of fuel—terribly short of it. Italy produces no fuel at all. Germany holds the coal fields of France, the oil fields of Roumania and Galicia and will reach for the oil fields of Russia bordering upon the Caspian Sea. The coal producing industry of Great Britain is taxed to the utmost. The United States, with coal enough in its mines to supply the whole world for hundreds of years, was short last winter 50,000,000 tons. Can your imagination grasp that vast shortage? Can you visualize a train of loaded coal cars more than 9000 miles long—the present fuel shortage of your country? The United States heedlessly and needlessly wastes 150,000,000 tons of coal each year—enough to cover our fuel shortage and in addition meet our entire war demand, estimated at 100,000,000 tons. Can you visualize a train of loaded coal cars 28,000 miles long—the fuel wasted in 1917 in the United States of America? You wasted your share of it. Think of that!

It is estimated that in house heating plants, due to their fires, leaks, lack of insulation and careless firing, only 25 per cent of the heat in the fuel is utilized; whereas, with these faulty conditions corrected, 75 per cent might be made useful. The gas analyses will reveal defects in furnace performance of a hot air furnace, hot water or steam house heating boiler as readily as for a power plant. If 1500 lb. of coal can be made to do the heating heretofore done by 2000 lb., the saving in a winter's fuel bill will pay several times over for the cost of an analyzer.

Skillful firing in place of careless firing and knowledge in place of guesswork will accomplish wonders in relieving the coal situation and reducing the cost of living.

THE FORCE TO DO IT. A LEAGUE OF NATIONS. BY HERBERT S. HOUSTON. MEMBER OF THE CHAMBER OF COMMERCE OF THE U. S. A. ON ECONOMIC RESULTS OF THE WAR*

EVEN while the present war was waged, a pledge to use economic pressure was made as a threat to avert a new war. The business men of America, in February, 1918, took the unprecedented action of serving definite notice on the business men of Germany that they will not hesitate to use a trade embargo against Germany, unless she lessens the danger of future war by reducing the size of her armaments. This notice, published to the world, was embodied in a formal referendum submitted to the 600,000 business men in the hundreds of commercial organizations making up the Chamber of Commerce of the United States; and, voting as organizations, they endorsed it by a vote of 1204 to 154. In the printed explanation accompanying the referendum it was stated that the action proposed "involves no thought of revenge or punishment, but is based on the logic that only through industrial intercourse with the United States can the military party of Germany get the sinews with which to precipitate a second great world war." The point was emphasized that the size of Germany's armament, after the war, could determine the size of the defensive armaments maintained by other nations; and, with unescapable logic, it was argued that the size of Germany's armanent would depend on her after-war receipts of raw materials and on the profits from her foreign trade. And it was on the broad ground of preventing great armaments and thereby preventing future wars that affirmative support for the referendum was asked and the pledge of the organized business men of America secured to "enter an economic combination against Germany if governmental conditions make it necessary for self-defense."

The Merchants Association of New York gave a negative vote on this referendum for the reason, as stated, that "while in entire accord with the sentiment and purpose," expressed in the referendum, "the association believes that the proposed method is neither the most appropriate nor the most effective for accomplishing the end sought. The international co-operation which it implies is more properly a function of government and can better be accomplished through governmental channels than through the intervention of unofficial commercial bodies." This dissent is clearly based on method and not on the use of economic pressure by a league of nations to prevent war.

While there was some opposition based on the ground taken by the Merchants Association of New York, the referendum was carried by a great majority. But this action must in no wise be interpreted as identifying the business men of America with the Paris Economic Conference held before the United States entered the war, or construed into support of the plans there considered. In fact, a broad disclaimer of any such purpose or intention was expressed in the statement, "We believe the American people will not join in discrimination against German goods after the war if the danger of excessive armament has been removed by the fact that the German government has in reality become a responsible instrument controlled by the German people."

This significant referendum can fairly be considered a challenge to the business men of Germany, from the business men of America, to prevent a disastrous economic war, by holding back the Junker and militaristic party from mad preparation for future war when peace finally comes. It is in full accord with President Wilson's statement of American war aims in his address of Jan. 8, 1918. The third of these aims proposed "the removal so far as possible of all economic barriers and the establishment of an equality of trade conditions among all the nations consenting to the peace and associating themselves for its maintenance." It is interesting to state that "equality of trade" was limited by the President in this same address in a way that permits of most effective use of economic pressure as explained in another chapter.

But clearly, in all this discussion, business and political, there is emerging a powerful international force, economic pressure, that the world must reckon with. In February, 1918, in the United States Senate, Senator Owen presented a resolution stating that "The United States believes that under a general association of nations it should be a violation of international law and the highest international crime for any nation on any alleged ground to invade by military power the territorial limits of another nation and that the penalty for such invasions should be the immediate international blockade of the invading and offending nation; an embargo on all mail, express and freight to and from such nation and the suppression of such invasion by the combined forces of the general association of nations organized for the protection of world peace."

And at about the same time the British Minister of Blockade, Lord Robert Cecil, gave public expression to his belief that economic pressure would be a powerful weapon for a league of nations to use against a recalcitrant nation. To this declaration he added this definite personal commitment: "I would not remain for an hour a member of any government which did not make the arrangement of a league of nations after the war one of its main objects."

Mr. Walter Runciman, in November, 1917, gave it as his view that "The only sense in which a league of nations can be reasonably contemplated is in that defined by President Wilson. . . . A league which would, in effect, penalize Great Powers must have behind it a great sanction. . . . I look around in every direction in vain for a sanction, except that of the economic offensive."

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American Business and the League of Nations

American business men had gone on record in favor of economic pressure over two years before the referendum, already outlined, was submitted to vote. In fact, economic pressure has its place in the League of Nations program through their support and approval. When the proposals of the League to Enforce Peace were being formulated in Philadelphia in June, 1915, the author undertook to state briefly the ground for believing that that pressure would have been strong enough to have compelled Austria to present her case against Serbia for a hearing.

The third proposal in the league platform of principles was under discussion, the one having to do with the sanctions to put behind a court. After full agreement had been reached on the use of military power as a sanction, I proposed, as a representative of the Chamber of Commerce of the United States, that economic pressure be made a preliminary sanction, in the third plank of the platform, to be followed by military power as a final sanction and it was embodied in a modified form in the third proposal, as follows:

> The signatory powers shall jointly use forthwith both their economic and military forces against any one of their number that goes to war, or commits acts of hostility against another of the signatories before any question arising shall be submitted as provided in the foregoing.

My purpose in following this economic pressure proposal from its introduction through its first and then into its final form in the platform of the League to Enforce Peace, is to make clear and to emphasize the point that this distinctly commercial sanction which will affect business profoundly when put into effect, originated with business men, was presented by business men for adoption in the platform of the league and then ratified by the business men of America in an overwhelming majority when submitted to a referendum by the Chamber of Commerce of the United States. If this be treason to the business of the world the business men of this country must accept the responsibility after prolonged consideration of all the consequences. At the national convention of the Chamber held in Washington in February, 1915, I had offered a resolution urging "that the next Hague conference provide as a penalty for the infraction of its conventions that an embargo shall be declared against an offending nation by the other signatory nations." This was referred to a committee on international affairs that was constituted to consider it, under the chairmanship of Edward A. Filene, of Boston. The committee unanimously agreed to the presentation before the Independence Hall conference of economic pressure as a sanction to be employed by the proposed League of Nations. As has been stated, this presentation was made and the sanctions adopted and the third plank included "the combined economic and military powers" of the signatory nations. This provided for the use of these powers concurrently and not in sequence as the committee of the Chamber of Commerce urged. But the committee joined heartily in support of the new league.

Then, in an endeavor to enlist the active support of the business men of the country for the program of the league, the committee of the Chamber of Commerce of the United States prepared a comprehensive referendum on the league's four proposals and this was submitted to the 600 constituent commercial bodies at that time comprising the Chamber. The result was an overwhelming majority in favor of the use of economic pressure and a much smaller majority in favor of the use of military power. With this mandate of the business men of the United States behind them, the three members of the Chamber of Commerce on the executive committee of the League to Enforce Peace, Mr. Filene, Mr. Gadsden and myself, pressed for an interpretation of article three that would square with the business men's view as to the place which economic pressure, a commercial sanction, should have in the plan for the League of Nations. And this interpretation was secured by the action of the executive committee which authorized the following:

> The signatory powers shall jointly employ diplomatic and economic pressure against any one of their number that threatens war against a fellow signatory without having first submitted its dispute for international inquiry, conciliation, arbitration or judicial hearing and awaited a conclusion or without having in good faith offered so to submit it. They shall follow this forthwith by the joint use of their military forces against that nation if it actually goes to war or commits acts of hostility against another of the signatories before any question arising shall be dealt with as provided for in the foregoing.

It can be definitely claimed, therefore, for economic pressure, in a plan proposed by the Leage to Enforce Peace, that it stands for the settled conviction, reached after full discussion, consideration and referendum of the business men of the United States. By them it is submitted to the judgment of the world.

Short Rules for Radiation

FOR minimum amounts of steam radiation surface to be installed in heating systems, based on 70 deg. inside and 10 deg. outside temperatures, the Chicago Master Steam Fitters' Association has adopted the following figures:

Provide 1 sq. ft. of radiation for:

- Every 300 cu. ft. of contents.
- Every 15 sq. ft. net of exposed wall area.
- Every 2 sq. ft. of window opening.
- Every 2 sq. ft. of door opening.
- Every 30 sq. ft. plastered ceiling with unheated air space above.
- Every 20 sq. ft. ceiling plastered on roof joists.
- Every 10 sq. ft. open joist or concrete roof surface.
- For rooms with northeast or northwest exposure, provide 10 per cent additional radiation.
- For radiators under seats or grills add 20 per cent of surface.
- For direct-indirect system, provide 25 per cent additional of radiation; and for indirect systems, add 50 per cent.
- Radiation surface required for hot water systems should be 60 per cent greater than for steam.
- Vapor systems should have 20 per cent more radiation than steam. A vapor system is defined as a 2-pipe system with returns open to atmosphere and no

valve at the return connections of heating units to close against steam.

For rooms to be heated from 10 deg. to temperatures other than 70 deg., the radiation computed as above should be multiplied by the factors following: 65 deg., 0.94; 60 deg., 0.87; 55 deg., 0.81; 50 deg., 0.75; 45 deg., 0.69; 40 deg., 0.62.

Steam Main Sizes

For a one-pipe circuit system with end dripped:

1-in main will care for radiation up to 60 sq. ft.;
1¼-in. up to 100 sq. ft.;
1½-in. up to 200 sq. ft.;
2-in. up to 400 sq. ft.;
2½-in. up to 600 sq. ft.;
3-in. up to 900 sq. ft.;
3½-in. up to 1,400 sq. ft.;
4-in. up to 2,000 sq. ft.;
5-in. up to 3,300 sq. ft.;
6-in. up to 4,500 sq. ft.;
7-in. up to 7,000 sq. ft.;
8-in. up to 9,000 sq. ft.;
9-in. up to 11,000 sq. ft.;
10-in. up to 15,000 sq. ft.;
12-in. up to 24,000 sq. ft.;

Horizontal branches, if more than 12 ft. long, should be increased 2 sizes above those called for by the above table; and if over 16 ft. long, should be properly dripped.

Dry returns shall be not less than half the diameter of the supply, but wet returns may be one size smaller than half the diameter of the supply.

Risers

For up-feed risers, use sizes as follows:

1-in. up to 25 sq. ft. radiation;
1¼-in. up to 60 sq. ft. radiation;
1½-in. up to 100 sq. ft. radiation;
2-in. up to 200 sq. ft. radiation;
2½-in. up to 350 sq. ft. radiation;
3-in. up to 900 sq. ft. radiation;
3½-in. up to 1,200 sq. ft. radiation;
4-in. up to 2,000 sq. ft. radiation;

Radiators should have a 1-in. connection for surface up to 25 sq. ft.; 1¼-in. up to 60 sq. ft.; 1½-in. up to 90 sq. ft.; 2-in. for anything above 90 sq. ft.

Horizontal supply pipes to radiators should be one size larger than the connections, unless for radiators with more than 90 sq. ft., when the supply may be the same size as the connection.

Heating Boilers

Based on manufacturers' catalog ratings, cast-iron up-draft boilers should be chosen with capacity 80 per cent greater than the actual amount of radiation in radiators and coils to be served. Down-draft cast-iron boilers should have 60 per cent excess capacity. Steel fire-box, brick set, up-draft boilers should have 35 per cent excess and down-draft of similar type 40 per cent excess.

At a recent meeting of the Naval Consulting Board, D. W. Brunton, of Colorado, was elected a member of the board.

Need of National Trade Mark

THE need of a national trade mark was urged recently at the spring meeting of the National Retail Dry Goods Association at Chicago by Chauncy P. Carter of the Bureau of Foreign and Domestic Commerce, who had an important part in drafting the national trade mark bill now before Congress, said recently:

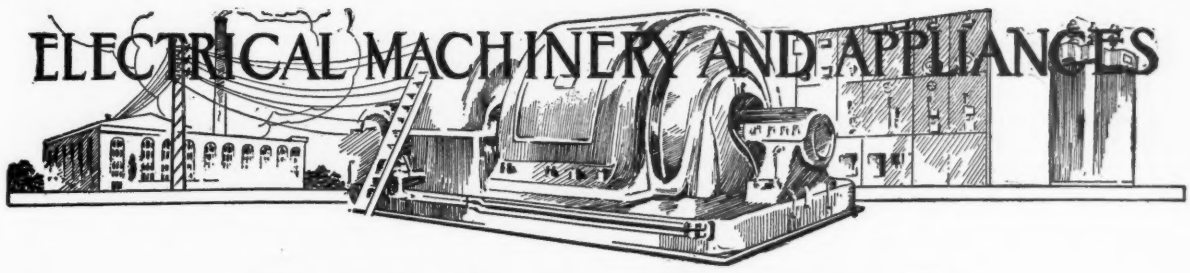
"One reason why a national trade-mark would be of great benefit to the American manufacturers is because there is so much legalized piracy of private trade-marks in foreign markets. The average manufacturer in this country does not consider export business until he has begun to exhaust the possibilities of the home market. In the meantime it never occurs to him that he ought to protect his trade-mark in foreign countries. See what happens, though: A New York exporter purchases some of his products and sends them to a certain country in South America. The buyer there finds that they will sell well and writes back to the New York exporter for an exclusive agency. Naturally, the exporter is not able to give him an exclusive agency nor is he anxious to put him in direct touch with the manufacturer. What does the South American merchant do then? He finds that the manufacturer's trade-mark is not registered in his country so he takes out a registration in his own name. Some years later the manufacturer decides to enter the export field; he inserts advertisements in export journals and soon secures an order from a reputable concern in that same South American country. The order is accepted and the goods shipped, but lo and behold! when they reach their destination they are confiscated and held upon complaint of the other merchant who cites his trade-mark registration as proof of his ownership of the mark, also adducing evidence to show that he was the first user of the mark in his country; and he has the law on his side.

"If we had a national trade-mark, owned and protected by our government, this American manufacturer could outwit the pirate merchant by merely substituting the national trade-mark for his private mark on all shipments to that country."

Use of the mark should be granted, it was urged, only to the manufacturers of goods that reflect credit on the industries of the country.

It was also pointed out that the measure providing for a national trade-mark was only one of a number now being put in shape and considered by the Department of Commerce with a view to preparing the American manufacturer and exporter to hold his own in the struggle for world trade that is expected to follow the making of peace.

The Swiss Federal Council, under date of April 19, 1918, has decreed that the Swiss transportation systems, the management of the telegraph system, the customs service, the federal government works and the remaining institutions under federal government management shall, upon the return of normal conditions, but not before May 1, 1919, establish the 24-hr. day, numbering the hours from 1 to 24, beginning at midnight. The Swiss Federal Railway Department is empowered to fix the definite date upon which the 24-hr. day is to be enforced.



Electric Storage Batteries---II

RATING OF BATTERIES; MAINTAINING ELECTROLYTE EFFICIENCY

THE VOLTAGE of storage battery cells varies but little, so that for any given illustration the number of cells required may be readily obtained by dividing the maximum number of volts required by the lower voltage value of the individual cells. In the lead-acid type battery, the voltage varies from 2.04 to 2.12 v., according to the strength of the electrolyte and the temperature while in the alkaline battery such as the Edison, the initial open circuit voltage is approximately 1.5 and that at the end of discharge about 1 v; the average voltage on discharge is approximately 1.2.

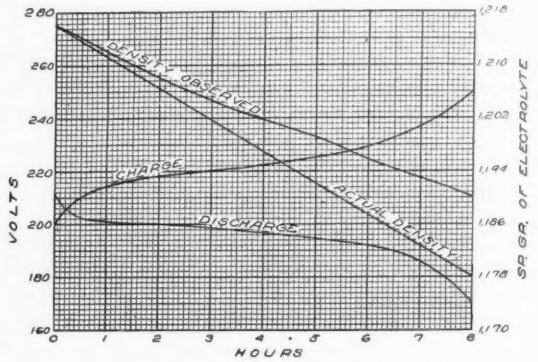


FIG. 17. CHANGE OF VOLTAGE AND SPECIFIC GRAVITY OF ELECTROLYTE OF LEAD CELL DURING CHARGE AND DISCHARGE

An approximate value of the electromotive force in volts may be obtained by the following formula presented by Streintz:

$$E = 1.850 + 0.917\ (G - g)$$

Where E is the electromotive force in volts, G is the specific gravity of the electrolyte and g the specific gravity of water at the temperature of the cell.

The capacity of a storage battery cell is expressed in ampere-hours or the product of the current in amperes times the number of hours the cell can deliver the current when operated between the practical limits of charge and discharge and is dependent upon the plate surface exposed to the action of the electrolyte, the number of plates, their character, the rate of discharge and the temperature. Ordinarily capacity rating is based upon a temperature of 70 deg. F. and the standard discharge rate for stationary cells of the lead type is on the basis of an 8-hr. discharge, allowing 6 to 7 amp. per sq. ft. of positive grid area. The discharge rate in amperes should never exceed four or five times the normal rate of discharge; but if of necessity the flow of current should at any time be greater than this, it should be for but a few minutes and then only with the battery fully charged.

Under conditions allowing regular periods of charge and discharge the charging should never be done at a very slow rate, as this is injurious to the cells. The current flow should never be less than about one-fourth of the normal discharge rate of the cell, although after the battery has approached complete charge, and especially after "gassing" begins the rate of charge may fall somewhat below this value. A good rule to follow for rapid charge is to deliver to the battery 35 per cent of the total ampere-hours during the first hour; 52 per cent during the next two hours; and 14 per cent during the fourth hour. On this basis a 200-amp.-hr. cell may be completely charged in 4 hr. by using a charging current of 70 amp. during the first hour; 52 amp. during the second and third hours; and 28 amp. during the fourth hour.

From the discussion of the theory of the lead-sulphuric acid cell, we find that with discharge of the cell a portion of the sulphuric acid combines with the lead and lead oxide to form lead sulphate with the result that the strength of the electrolyte becomes depleted and as a consequence the specific gravity drops. Similarly the charging process results in a reversal of this action with an accompanying increased strength of

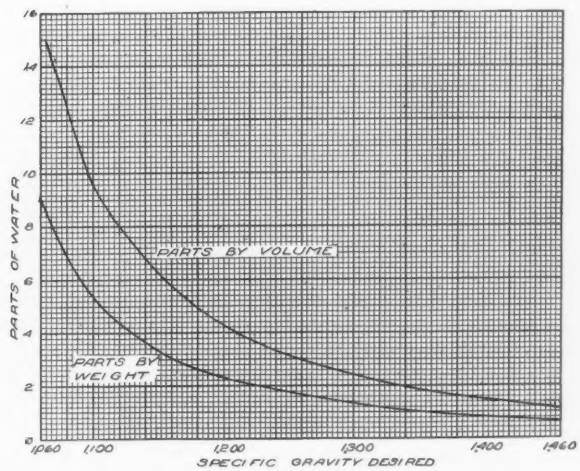


FIG. 18. RELATIVE PROPORTIONS OF WATER AND SULPHURIC ACID USED IN PREPARATION OF ELECTROLYTE

electrolyte and higher specific gravity. It is, therefore, obvious that although the condition of the battery may be readily determined by the voltage reading, the specific gravity of the electrolyte is a more accurate indication of the state of charge. Typical charge and discharge curves are shown in Fig. 17.

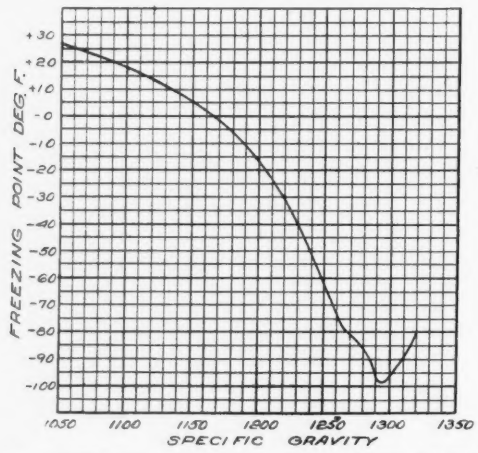


FIG. 19. FREEZING POINTS OF ELECTROLYTE OF VARIOUS SPECIFIC GRAVITIES

The quantity of electrolyte in ounces required for a cell of 100 amp.-hr. discharge capacity may be obtained by dividing 1279.5, times the per cent of sulphuric acid in the electrolyte at the end of discharge, by the difference between the per cent of sulphuric acid in the electrolyte at the beginning of discharge and that at the end of discharge. For a capacity other than 100 amp.-hr., multiply the result thus obtained by the quotient of this new capacity in ampere-hours divided by 100.

In preparing electrolyte for acid batteries, concentrated sulphuric acid, which is a heavy, oily liquid having a specific gravity of about 1.835, is used, but in order to obtain the best results, this must be diluted with a sufficient quantity of pure water to bring the gravity down to 1.270 to 1.300 with the battery fully charged. An electrolyte stronger than this is injurious. The proportions of water to sulphuric acid required to be used for any degree of specific gravity desired may be obtained by referring to the curves shown in Fig. 18, taken from the publications of the Electric Storage Battery Co.

It is of particular importance that a glass, china, earthenware or lead vessel be used in preparing the mixture and under no conditions should the water be poured into the acid. Always carefully pour the acid into the water and stir well with a wooden paddle, allowing the mixture to cool before taking a gravity reading.

The freezing point of the electrolyte varies with its specific gravity and it is, therefore, necessary in the case of batteries subjected to low temperatures to see that the charge is at all times sufficient to maintain the specific gravity at such a point as will prevent freezing. The freezing points of electrolyte of different specific gravities are shown in the curve, Fig. 19.

Specific Gravity Readings

For all practical purposes these readings may be obtained by means of a hydrometer which consists of a weighted glass bulb with graduated stem. See Fig. 20. In strong acid, that is, where the specific gravity is high, the stem protrudes considerably above the surface of the liquid and the point at which the meniscus touches the scale is read directly as degrees of specific gravity. With a weak solution the hydrometer will sink to a point depending upon the density of the solution, but the specific gravity may be read in the same way.

Portable batteries and those used in vehicle work are built very compact and, due to the sealing employed, the interior is inaccessible except through the filling and vent plug. To determine the specific gravity of the electrolyte of such cells, it is, therefore, necessary to take the readings outside of the cells, most readily accomplished by means of a syringe hydrometer such as shown in Fig. 21. The hydrometer proper is similar to the other, but floats within the enlarged portion of the glass barrel when the electrolyte is sucked into it by means of the rubber bulb.

Hydrometer readings should always be taken before adding fresh water to the electrolyte and whenever a number of cells are being worked upon, care must be exercised to prevent taking electrolyte out of one cell and after the reading has been taken, discharging it into another. Mixing the electrolyte in this manner has a tendency to render worthless the readings taken.

Adding Water

Due to natural evaporation and "gassing," more or less electrolyte will be lost and as it is only water and not the sulphuric acid which evaporates this must be replaced from time to time. Never allow the level of the electrolyte to recede below the tops of the plates

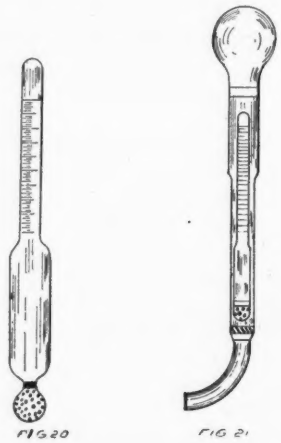


FIG. 20. HYDROMETER
FIG. 21. SYRINGE HYDROMETER

and when it becomes necessary to add water, only distilled or clean rain water should be used.

Naturally, some impurities will exist in the water used for replacement of that evaporated, but under no conditions should such impurities exceed the maximum limits given in the following table:

Color	Colorless
Suspended matter	Trace

Nitrates as NO_3	1.00 parts per 100,000
Total solids	10 parts per 100,000
Calcium and magnesium oxides	4 parts per 100,000
Iron	0.05 parts per 100,000
Ammonia as NH_4	0.80 parts per 100,000
Organic matter	0.10 parts per 100,000
Nitrates as NO_2	0.50 parts per 100,000
Chlorine	1.00 parts per 100,000

Efficiency of Storage Batteries

Like any other mechanical or electrical device, the storage battery cannot deliver as much energy as is put into it. Ordinarily the efficiency of lead batteries is about 70 per cent, although under certain conditions this figure may be increased to as much as 95 per cent. With the battery discharged to 1.8 v. per cell, then completely charged, then discharged to 1.8 v. per cell and so on, the efficiency varies from about 70 per cent with high rates of charge and discharge to about 80 per cent with low rates of charge and discharge. If the charge and discharge periods occur through a very narrow range during short intervals of time, a condition such as is found in automobile lighting and starting service, where one moment the battery is charging and the next moment discharging, the efficiency may be as high as 93 or 94 per cent.

The efficiency of the Edison battery is said to be about 60 per cent.

Starting Rotary Converters

Comparison of Results With Transformer Secondaries Permanently Connected to Collector Rings and When Alternating-Current Circuit is Open. By F. D. Newbury and M. W. Smith

When there are no switches between the collector rings of a rotary converter and its transformer secondaries, the latter act as shunts to the converter armature and divert a considerable part of the starting current from the armature. This effect is greatest when the armature happens to stop in such a position that the direct-current brushes and the alternating-current collector ring taps are connected to the same coils, a condition which may exist with a two-phase or diametrically-connected six-phase unit, since both direct-current and alternating-current connections to the armature are spaced 180 electrical degrees. The shunting effect is a minimum when the tap coils have a maximum displacement from the coils connected to the direct-current brushes. In a two-phase armature this position of minimum shunting effect (and maximum starting torque) is 45 electrical degrees from the position of maximum shunting effect. This change from minimum to maximum torque occurs during a very small part of a revolution—in a converter with 14 poles it is 1/56 of a revolution or about six mechanical degrees. If the armature stops in the position of minimum torque, the torque can be doubled by turning the armature only two commutator bars. In such a case barring the armature by hand for a short distance may bring it to a position where it will have sufficient torque to overcome the initial starting friction.

The extent of the reduction in starting torque caused by the transformer secondaries is, of course, affected by the relative resistances of the armature and transformer. In a rotary converter, the armature resistance is high (due to the small effective current in the armature when operating as a converter) and may be as much as five times the resistance of a single secondary winding. Assuming this ratio and further that the starting current will be constant for the different positions of

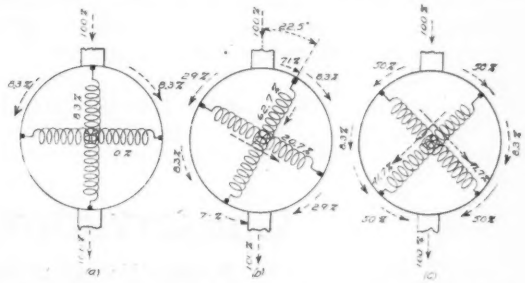


FIG. 1. ARMATURE AND TRANSFORMER CURRENT VALUES FOR VARIOUS POSITIONS OF ARMATURE

the armature (the resistance in the starting rheostat is very large as compared with the converter and transformer and will largely determine the current), the armature and transformer currents will be as shown in Fig. 1, (a), (b) and (c) for three positions of the armature. If it is assumed that the torque produced is proportional to the average current in the armature winding (this is only roughly correct, as the magnetic field varies in density to a considerable degree at different points in the air-gap), the torques in the different armature positions vary from 16.7 per cent of the torque that would exist with the secondaries disconnected in the position shown in (a) to 58.3 per cent of this torque in the position shown in (c). The variation in torque for a complete revolution of a two-pole converter is shown in Fig. 2.

With a six-phase diametrically-connected converter, the reduction in torque due to connected transformer

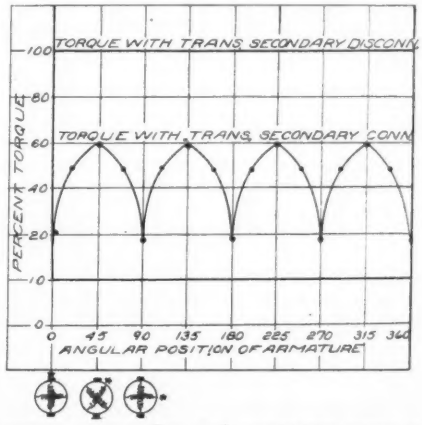


FIG. 2. TORQUE VARIATION FOR COMPLETE REVOLUTION OF TWO-POLE CONVERTER

secondaries is even greater, due to the presence of three secondaries, instead of two. With a three-phase or delta-connected six-phase converter, the reduction in torque is considerably less, because in no position of the armature does a transformer secondary completely parallel the armature.

The previous explanation refers only to conditions as they exist before the armature begins to turn. As soon as rotation begins, alternating-current flows in the armature and transformer secondaries that further reduces the starting torque, due to its demagnetizing effect on the converter field.

As a result of both these effects, a converter with solidly connected transformers requires several times more starting current when started from the direct-current side than when the transformers are dis-connected.

The obvious remedy in this case is to provide at least one switch in each transformer secondary and open these switches before applying the direct-current starting voltage. It will be advisable to have the synchronizing equipment on the low voltage side of the transformers.

A further difficulty will arise if the shunt field should be connected directly across the armature. The shunt field should be connected on the line side of the starting resistance so that full line voltage is applied to the field on the first step of the starting rheostat. If the shunt field is connected across the armature, the field strength and hence the starting torque, will be weak, due to the voltage drop in the starting resistance. In such a case barring would be of assistance only in overcoming the initial mechanical friction and the machine probably would not start at all.—THE ELECTRIC JOURNAL.

Conservation of Ammonia-IV

FOREIGN MATTER IN THE AMMONIA SYSTEM, OIL, MOISTURE AND AIR, AND THEIR REMOVAL. BY A. G. SOLOMON

THE third reason for ammonia loss in the refrigerating system is the deterioration caused by the introduction of foreign matter.

The highest discharge temperature reached in the operation of the ammonia compressor is not high enough by several hundred degrees to cause disintegration. We often hear that the ammonia is being burned up, but such a statement has no foundation. It takes a temperature of about 900 deg. to render ammonia unfit for refrigerating duty.

But the temperature at which compressors are operated will have a harmful effect on ammonia which is not pure; and the ammonia in a great many systems is so full of impurities that deterioration is continually going on. The common impurities introduced in the system are oil, moisture and air. These, when mixed with the pure ammonia and subjected to heat, cause great loss in effective service. Where the impurities are present, they are circulated through the entire system and require power but do no collecting of heat units. Frequent purging of the condensers is often resorted to in an effort to rid the system of the noncondensible gases.

OIL TRAPS

OIL is the most common of the foreign substances allowed to enter the system. We must use a certain amount of oil to lubricate the compressor valves, cylinder and piston rod, but the oil must be taken out of the system after it has done its duty as a lubricant.

Provision is made by all builders of refrigerating machinery for the removal of the oil. The first consideration is the kind of oil and no oil except such as is made especially for ammonia compressors must be used.

And none but the best rod packing must be used, for the reason that the best packing requires less lubrication and most of the oil which enters the system is intended for rod lubrication. With the proper grade of packing and the best oil, but little lubrication is needed. The less oil used, the less has to be prevented from going to the evaporating coils.

Measure all the oil that is used and also all that is drawn out and see that the amounts tally, after allowing a small per cent for that which will gasify and remain in the system.

When a compressor or any part of the system is pumped down below atmospheric pressure, be sure that the oil supply to the rod is shut off. Failure to do this will allow an unnecessary amount of oil to be discharged to the condenser. Oil will pass through the oil lantern and gas relief line and into the compressor when there is a vacuum created in the compressor during even a short part of the stroke.

Oil traps are provided for the trapping and withdrawing of such oil as does enter the system. The oil trap on the discharge line is the most important and should be emptied at regular intervals when the plant is in regular operation. Do not empty any oil trap unless it is necessary and do not blow out ammonia with the oil. By this I mean do not empty a trap once a day when there is very little oil being used and as soon as the oil stops flowing, shut the drain valve. The light, frothy looking oil that is often drawn out contains so much ammonia that the loss is considerable. Allow enough oil to collect before drawing out so that but little ammonia is contained in it.

In a system where it is known that oil is present in the evaporating coils, the discharge trap must also be emptied when any part of the system has been pumped down below the usual working pressure. The lowered pressure causes rapid evaporation of the ammonia and the oil in the coils will be drawn to the machine. Another time that a large amount of oil must be looked for is when an ice tank or cold storage room has been allowed to reach a higher temperature than usual.

Oil traps are placed in different parts of the system. Besides the discharge trap, what may be called the suction trap is often found. This is to intercept oil coming from the evaporating coils and before it reaches the compressor.

The bottom manifold or header in ice tanks is also a trap for oil and should be blown out frequently.

In a system having several traps I have found it good practice to have a certain day for the emptying of the different traps. In such a system, an ammonia purifier is almost a necessity; but if a real purifier is

not provided, a receiving tank can be made from material which will be found around the plant. The drain lines from all the oil traps are connected into the purifier or receiver and this in turn is provided with a line connecting into the suction side of the system.

Blow down all the oil traps into the purifier and then allow the ammonia to escape to the suction. In this way, very little ammonia is lost when the oil is drawn out.

Oil in Coils

If the ice tank or cold storage coils are known to contain a considerable amount of oil, they must be cleaned out with steam and air at the first opportunity.

Oil is harmful in two ways. First, it insulates the coil and reduces the rate of heat transfer from the produce to the ammonia; second, oil is an impurity and as such causes deterioration of the ammonia.

Moisture

The next impurity to be considered is moisture. It seems almost impossible that water can enter the ammonia system, but it is nevertheless true. Its presence in contact with the ammonia is very harmful owing to its absorbing power.

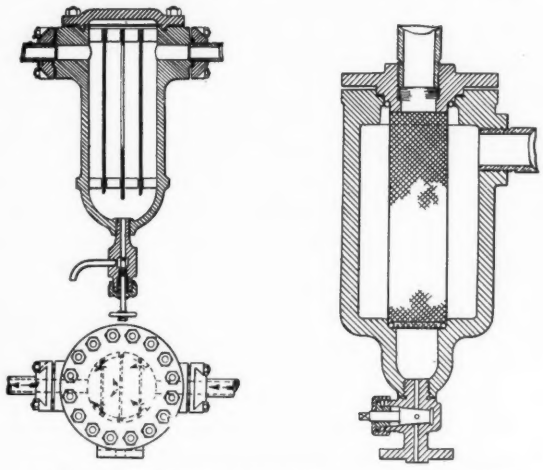


FIG. 1. TYPES OF OIL SEPARATOR. A, BAFFLE TYPE; B, WIRE SCREEN TYPE

Moisture can get into the system in several ways, one of the most common being by pumping water through the oil lantern with the oil. This happens where the oil supply is contained in a pan or box placed beneath the stuffing box. Melting of the frost on the suction side of the compressor will allow small amounts of water to drip into the oil and the oil pump passes it on to the system by way of the gas relief line. Where this method of rod lubrication is used, every precaution must be taken so that there can be no possibility of water mixing with the oil.

Water can also enter the compressor through leaks in joints that are submerged in the water jacket. When the compressor is being operated normally, ammonia will escape into the water; but if a vacuum is created in the cylinder, the water will enter through the leaks. To guard against this, it is always best to drain the water jackets when the pressure is reduced below that of the atmosphere. This lowering of the pressure may, in some plants, be a very rare occurrence; but if it happens only once a year, the water jacket should be emptied.

Never operate the compressor with the suction valve closed or even partially so. This practice is not common, but in some plants handling a direct expansion system the suction valve at the compressor is often partially closed when the machine freezes up. The freezing up is caused by the ammonia gas returning from the evaporating coils in too heavily saturated a state. To overcome this condition, the coil from which the liquid is coming must be located and the expansion valve closed. In extreme cases the outlet valve on the coil may be closed all but about one turn.

If the compressor shows signs of getting enough liquid to cause damage, the machine should be slowed down and operated at a slow speed until the liquid has been pumped out or checked at the coil from which it is coming.

When the suction valve is partially closed, the moving piston will cause a vacuum to exist for at least a part of the stroke; and if there is a small leak at a valve bonnet or head gasket, water will be drawn in.

Water is exceedingly hard to remove from the system, as it goes through the discharge line in the form of light spray or steam and the oil trap does not stop much of it. It will then pass through the condenser, liquid receiver and liquid line and enter the evaporator with the ammonia. Here the low temperature will cause the moisture to be deposited on the walls of the coils and there it will remain, doing its work of destroying pure ammonia as well as acting as an insulator.

As a precaution against the introduction of moisture, do not lower the pressure on any submerged ammonia coils below atmospheric pressure plus the pressure added by the weight of the brine or water in which the coils are submerged.

Never under any circumstances pump a vacuum on a submerged coil which is suspected of leaking, and do not pump a vacuum on anything unless it is absolutely necessary.

Other causes of moisture in the system have been treated in the discussion of invisible leakage.

Air or Noncondensible Gases

When repairs or changes have been made in any part of the ammonia system air has been allowed to enter.

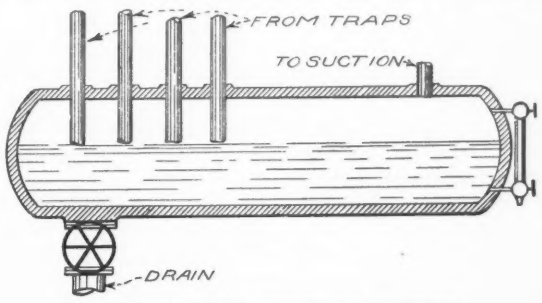


FIG. 2. AMMONIA PURIFYING RECEIVER

This air must be drawn out before ammonia is turned in. The usual manner of withdrawing air is to use the compressor and pump a vacuum on the part that is filled with air at atmospheric pressure.

Provision must be made at the compressor to discharge the air to the atmosphere, which is done by opening a valve intended for the purpose or else disconnecting one of the bypass lines.

When this air removing is to be done, the engineer must be careful not to discharge ammonia to the atmosphere. If ammonia is present, it is proof that some valve is leaking. In such a case, it is better to allow the air to remain in the system until it can be purged out at the condenser.

When new coils are installed in a plant already in operation and when testing the overhauled coils while others contain ammonia, the greatest care must be taken not to force air into the ammonia. Do not depend on a valve between a coil being tested with high-pressure air

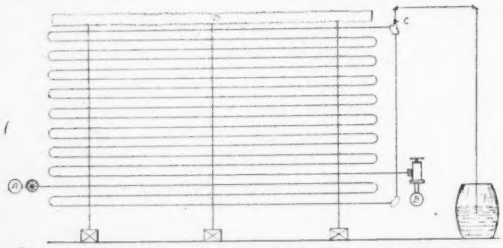


FIG. 3. CONNECTIONS FOR ATMOSPHERIC CONDENSER AND PURGE VALVE. A. HOT GAS HEADER; B, LIQUID HEADER; C, PURGE VALVE; D, SPRINKLING TROUGH

and another part of the system containing low-pressure ammonia. The valve may leak and the system become filled with air. Blank off the coil being tested and do not connect it to the system until the testing is completed and the air is to be removed by the pumping of a vacuum.

Air will also enter a system if the back pressure is carried below atmospheric pressure, as is sometimes done when extremely low temperatures are maintained. When this unusually low back pressure is carried, the rod packing must receive special attention to prevent air leakage; and the rod lubrication must be watched closely, as air can enter by way of the oil lantern and gas relief line if the inlet oil line to the stuffing box is not properly sealed.

PURGING

WE KNOW that some air will get in no matter how careful we are and noncondensible gases will form owing to impurities with which the ammonia comes in contact.

When it is known that the system contains air and foreign gases, steps must be taken to get rid of them. Purging the condenser is the only means we have to clear the system of the noncondensible gases. Most engineers do not give the matter of purging very serious thought and by this neglect of forethought many pounds of good ammonia go to the outside air.

Do not purge the system unless it is absolutely certain that gases in a noncondensible form are present. The proof is furnished in several ways. First: Positive proof is had when a coil has been opened up and again turned into the system without first withdrawing the air; or when the compressor has been operated with the suction pressure below atmospheric pressure and a place has been found where air has been drawn in. Second: High condenser pressure and whistling sound at the expansion valves, although there is sufficient ammonia in the system to insure a liquid seal at the outlet of the liquid receiver. Third: Inability to frost back on the compressor when all conditions seem normal.

After the engineer is satisfied that there are noncondensible gases to blow out, he must see that the charge of ammonia is large enough to allow for the complete separation of the pure ammonia from the foreign gases.

Do not attempt to purge the condenser unless there is a full amount of ammonia in the coils to be purged. If a coil has only a small amount of ammonia in it and the purge valve is opened, the pure ammonia will rise and mix with the foreign gases and so be lost.

The proper way of purging is as follows:

Shut off all the expansion valves and pump down until the back pressure gage shows about 5 lb. pressure. If the condenser pressure is now at or below its usual point, shut off valves to A, Fig. 3, and pump out 1/5 of the coils of the condenser. This pumping out will put all the ammonia in as few coils as possible and will crowd the noncondensible gases into a small space. Allow the coldest available water to flow from trough D freely over the coils now containing the ammonia. All pure ammonia should be condensed and settled in a half hour.

Next, separate the condenser coils by closing all the inlet and outlet valves from A and B and purge each coil separately. Extend the purge line into a large pail or barrel which is provided with an overflow and a line to supply clean cold water. Open the purge valve C on one coil at a time and allow the foreign gases to escape slowly to the water in the barrel. The objectionable gases will show as bubbles rising to the top of the water. Ammonia will make a crackling noise when it enters the water. At the first trace of ammonia, shut the purge valve and go to the next coil.

All the air in the system will not be blown out at the first attempt. Purging may have to be done two or three times to rid the sytem entirely.

THE 1918 SUMMER SESSION of the University of Illinois will offer special advanced courses planned especially for instructors in mechanics in trade schools and technical schools, for chemists who wish to fit themselves to take positions involving the physical testing of materials, and for men who wish to fit themselves for positions in commercial or government testing laboratories. Three special courses will be offered:

1. Advanced Mechanics of Materials. Advanced problems in strength of materials. A knowledge of elementary mechanics of materials is a prerequisite for this course.

2. The Properties of Engineering Materials. Lectures and assigned reading on the properties of iron, steel, other metals, wood, brick and concrete. A knowledge of elementary mechanics is a prerequisite for this course.

3. Laboratory Work in Testing Materials. Study of testing machines and strain measuring apparatus; practise in standard methods of testing and tabulation of test results. A course in elementary mechanics of materials accompanied by work in the laboratory is a prerequisite for this course.

Further information concerning the courses and expenses may be obtained from the Director of the Summer Session, University of Illinois, Urbana, Ill.

A Letter from the Front to "The Army of the Rear"

A YOUNG American "C. L. W.," now an Artillery officer in the French Army, writes this urgent letter to his American friends, pointing out the real exigencies of the war. The daily routine of life at the front does not prevent "C. L. W." from keeping his eyes open. Nor does it keep him from thinking. He has some things to say in this letter that every stay-at-home American should note and remember.

"I remember that before I left New York you and many of my other friends said: 'I envy you going over there, old man, where the big things are doing.' Big things! * * * why, in the topsy-turvy world of the trenches, casernes, and depots I have found that life is just a network of trifles.

"A separate peace in Russia—that is an insignificant topic for a few minutes' conversation in the mess hall. Immorality—the subject of a few minutes' thought if one happens to sleep badly and wakes up at 2 in the morning. But the absorbing topics are these: The 6 o'clock 'moch was cold this morning; the new lieutenant insists on a douche and a change of linen every Sunday; the last lot of pinard wasn't fit for a carter to drink; on the magazine which you received from America this morning there was a purple stamp which I should like to add to my collection.

"We over here are absorbed in finding devices to keep warm at night; in schoolboy tricks in the barracks; in endless exercises with the grenade and bayonet; in minute study of the course and efficacy of tiny shell fragments. And down at the front they spend weeks watching a low dirt parapet or a clump of shattered trees.

"If you should draw a heart-shaped figure with its point resting on Chicago and its indentation on New York, and the two parabolas touching Washington on one side and Boston on the other, you would have the zone of the big things in this war as far as America is concerned—Chicago the food center, New York the money and shipping center, Washington the policy center, and our greatest industries included in its borders.

"On the pulsing of that great heart back home depends allied success or failure. Lucky people that live close to it—that are its blood and muscle. For you the great task of pumping vigor into depleted veins on this side; for you the magnificent duty of maintaining a healthy flow in the arteries of communication in land and water; for you the solution of the big political and social problems.

"I had to come to France to learn that it is the army of the rear, back in the States, that is going to win or lose the war. The Army in France will do nothing new or extraordinary in building several hundred miles of railroad to the front. * * * but it was a momentous event when Wilson pooled the equipment and management of the railroads of the United States. Our engineers are building several hundred kilometers of military highway, but the Romans did as much a couple of thousand years ago, and did it much better—so well, in fact, that we still use their foundations. * * * The important thing is: Will you send us the trucks and supplies to roll over these roads? The mere act of digging a trench is nothing in itself—the Wops are the best at it—but will you build the ships to send the men to fill them?

The men here have done a big thing in surrendering comforts and facing death, but in the meantime life is a dreary skein of nagging details, a series of sickening endurances against boredom, fatigue, and hunger—but principally against boredom.

"When I compare the importance of your work with ours I grow really envious. Before us we have the Boche—but alongside of you you have the pacifist, the defectionist, the selfish laborite, the greedy manufacurer and, worst of all, the loafer. I wish they could give you a sack of bombs and carte blanche to be after every loafer in field, factory, office, or Washington bureau.

"The administration has demonstrated its dependence on public sentiment, and there you have another big, interesting daily work. Of course, public sentiment is just your opinion and everybody else's added together and divided by 100,000,000. But to have the right opinion—to express it—to argue for it—to fight the element that seeks to use a crisis to further political aims—to watch for treason and expose it—there is a game worth playing, and I can imagine how thoroughly you are engaged in it with pen, voice, brain, and heart.

"It is you, who regretted staying home because you were missing the 'big things,' upon whom, after all, everything depends. It is you who, from a calm distance, with daily, complete news at your elbow, can form sane judgments, and if you will compare the sane action, that will justify our miseries and dangers.

"It is pathetic how the muddy, shivering soldier down there, engrossed in his little miseries and trifling joys, is dependent upon his comrade of the rear, who too often forgets his task, or even the existence of war—and yet it is he alone who can bring the soldiers back. The war has done badly so far because the Army of the Rear—from the shortsighted diplomat to the striking laborer—has failed to realize the size of his burden.

"The soldiers will do their little bit every day, never fear, but those behind the lines must be worthy of them. Have they been?

"In the meantime we must continue our flea hunting, our drills, our mathematics, and every once in a while take the big risk * * * and while you tackle the big problems our outlook is a few square kilometers of mud or a block or so of barracks, and our concern is whether the new lot of tobacco will arrive Wednesday and whether it will be horse or cow for supper."

AN ENGINEER in France is in the market for general electrical supplies such as dynamos, motors, transformers, insulating material, switchboards, etc. Quotations should be made f.o.b. New York and payment will be made against documents. Correspondence may be in English, and references as to the responsibility of the bidder are required. Further information may be had from the Bureau of Foreign and Domestic Commerce, referring to No. 26,988.

Operating Costs of Oil Engines

REGARDING THE inquiry of A. L. B. on page 425, May 15 issue, I would say that I can give a very definite answer as far as this one plant is concerned. It would be useless to go into details regarding the cost of producing power by the use of steam equipment, for the simple reason that any engineer who is in charge of a steam plant will already know exactly what his plant is doing along those lines.

In installing oil engine units, one has to figure that the original or first cost of the installation will be much higher than that of steam, as a 225-hp. oil engine will cost installed about $40,000. I'm speaking, of course, of an electrical unit, including compressor, generator building, freight, etc. Money today is easily worth 8 per cent. This means that the difference in interest alone between a $10,000 steam plant and a $40,000 oil plant at 8 per cent interest is $2400 per year, or $200 monthly. The upkeep of an oil unit is about four times that of a steam plant of the same size, depending a great deal on how heavily—how near its rated capacity—the engine is loaded. One reason for this is that Diesel engines need re-boring at least twice to a steam engine's once. On re-boring, one finds that new pistons for oil engines are much costlier than those of steam engines; also, new rings for the oil engine are needed much sooner than for the steam engine; and there are so many more things to the oil unit, which, getting slightly out of order, cause a big expense yet would hardly effect the engine driven by steam. Lubricating the oil engine is costly. In the splash type—A type—one needs to use at least 3 gal. each 24 hr. of the very best oil; this means at least $1.50 a day for lubrication. Water is another item, as it requires from 1000 to 3000 gal.—depending on the temperature of the water—to keep exhaust and needle valves cooled and which goes to the sewer. The main cooling water is not wasted and is used over and over again. On the B type engine, this wasted water of the A type is saved also.

Remember, in writing this I'm speaking strictly along the lines of personal experience and must, of a necessity, tell only of the make engine which I've used; i. e., the American-Diesel, or Busch-Sulzer-Diesel engine, for while I could quote and copy considerably, I do not think I'd be doing either myself or the reader justice, for A. L. B. evidently wants only one's personal experience. Other make engines may have a different rate of maintenance. But, with all this extra upkeep and faster depreciation, the oil engine is much the cheaper and more economical unit. In paying freight on coal, we pay for many tons of dirt. In firing with coal we must maintain a set of stokers or pay wages to firemen. In consuming coal under boilers, good authority claims at least 75 per cent goes up the stack. A. L. B. will know how many B.t.u. he has in his coal and how many eventually reach the switchboard. In using his oil engine, he will find that in paying freight for oil he pays for only that which is combustible, or all of it. In using this oil he dispenses with the services of stokers and firemen. For each 1800-1900 B.t.u. in a pound of oil he will get within 1 per cent of all of them out and in getting them to the switchboard will find that he has made them all do their bit. Of course, a neglected oil engine will be wasteful; but when it reaches a certain wasteful stage, he will have to fix it for she will then lie down and refuse to go, even if he does use the balky mule remedy and twist her tail. She just simply won't do it.

Oil costs this firm at the present time $4.85 per hundred gallons, delivered in our tanks. I am giving below a few days' run with the oil engine and showing the amount of fuel used to produce the given kilowatts at the switchboard. At this time of the year we run very light and especially so since the war came on and people are economizing; anyone running steam plants can make his own comparison.

Date	Kw. Produced	Gal. Fuel Used	Fuel Cost, Gal. Cents	Plant Labor 24 hr. Dollars	Lubrication 24 hr. Dollars	Average per Kw. Cents	Cost Fuel per Kw. Cents
4-2-18	2100	247	4.85	11.00	1.65	1.17	0.57
4-3-18	1900	193	4.85	11.00	1.65	1.16	0.49
4-4-18	2200	252	4.85	11.00	1.65	1.13	0.55
4-5-18	2000	238	4.85	11.00	1.65	1.29	0.57
4-8-18	2200	254	4.85	11.00	1.65	1.13	0.55
4-9-18	2200	252	4.85	11.00	1.65	1.13	0.55
4-10-18	1900	190	4.85	11.00	1.65	1.15	0.48

On going over my records from day to day, picking out any month or any year since we have been operating the oil unit, I find that my expenses have been practically the same, with the exception, of course, that when we first started using this unit, oil was delivered to us at $1.65 per 100 gal. and has gradually gone up and up until it now has reached $4.85 per 100 gal.; and today I have received my last car at that price and have been notified that it will be higher the next time.

If there is anything more that I can tell A. L. B. which would be of benefit or interest to him I shall at any time be glad to do so. I might say in addition that I have regularly visited two other Diesel plants and find that their expense account is practically that of ours.

JOHN PIERCE.

IN REGARD to your inquiry relative to cost of operating oil engines as compared with steam, I can give some interesting figures. We used steam in our plant up to June 27, 1917, and the average cost per million gallons of water pumped approximated $48 and the average

cost per million gallons with our Primm oil engines has been but a little over $9.

The horsepower consumed was practically the same. Below I will give a copy of my report on a trial run of 992 hr.

During the 992 hr. we pumped 17,749,000 gal. of water against a head of 220 ft. (static), delivering approximately 300 gal. per min. against a working head of approximately 240 ft.

We used 2465 gal. of fuel oil, which cost us a total of 5.4 c. per gal., or $133.21; lubricating oil, 50 gal. at 50 c. per gal., or $25.

We were pulling an actual load of 20 hp., or an actual 20-hp. load and using a 35 and 40-hp. Primm oil engine to do the work.

I would like to hear from others as I am also interested in the cost of operation of plants and if further information is desired I would be glad to furnish what I can, as I have had considerable experience with the different makes of oil engines, also with steam power. I think it will be found that no power will compare with oil for a low cost of operation. J. E. ROBERTS.

Feeding Shavings to Boiler Furnaces

IN THE ISSUE of May 15, D. J. B. is asking for a method of feeding shavings and hog dust to furnaces. The information that he gives in regard to the work to be done is rather meager, but I would suggest the following way of handling which I have proved eminently satisfactory:

If there is a place for it, a fuel house or vault should be constructed of reinforced concrete immediately in front of your furnace doors 6 to 8 ft. distant. Half way between the line of your furnace doors and this "dust house" locate a cyclone of the right capacity. Run one line of pipe out from your cyclone, discharge end, branch this, running one line to dust house, one line to furnaces. At point of intersection with main line from cyclone locate a two-way valve. Branch furnace line again, no valve, running pipe into furnace at highest point possible above fire line; these pipes should be flush with inside of fire doors and by branching furnace line as above, shavings will be fed into furnace at two points. The dust house should be equipped with two sliding doors immediately opposite furnace doors that can be raised up so that fireman may be able to fire from dust house by hand in case of emergency. This system gives you an automatic feed entirely adjustable as long as fan is running in factory and in case of shut down gives a supply of fuel to run with until factory is again in operation.

I might add that the "cyclone man" was right in that it would be suicidal to blow direct into furnaces.

This is a subject that I am very keen on as there is entirely too little known by the average man about installations of this kind. L. H. HILL.

I HAVE HAD a lot of experience in firing shavings and wood, coal, coke and sawdust. If your waste is in the form of wood, don't try to cut it up to be fed through a blower. There is more fuel value in it in the form of wood than any other way. A wood fire with coal and shavings on top is the hottest fire that can be made if you have good draft. Cut the wood in proper length to be fed to the boiler and give the fireman a little extra help if he can't handle it alone and use him so he will take an interest in his job and let him burn the waste as he thinks best, or if he has not had experience in wood firing, get a portable saw mill fireman to show him, as that kind of firing can only be learned by experience. It takes from 15 to 50 hp. to run a blower and hog and you had better pay a man to clean the shop and help the fireman out. If necessary, you had better sell the wood and buy coal than to go to all the expense of putting in a blower system that will not give you extra power enough to pay the gain in fuel which is not anything to speak of in your case. I consider that hand firing is the most economical and will obtain the best possible results. A. O. GATES.

I WOULD suggest that D. J. B. put an outlet between his cyclone and furnace with a damper in such a manner that he can let a part of his fuel go into a vault which he intends to build, the bottom of the vault should be inclined from both sides towards the center, there should be a hole about every 4 ft., say about 12 in. square, which can be closed with a slide; he should then install a slow running chain conveyor to empty into a hopper which should be connected to the suction end of the present blower system; the chain should be arranged that the fireman can start and stop it at will.

Of course, if the boiler room is a great distance from his present blower system, then this scheme is impractical. If D. J. B. decides to install a separate blower, I would advise putting in a separate cyclone, the blower company agent was very likely right, if shavings were blown directly into the furnace with a blower, it would result in a terrific hot fire. I would advise installing a Mitts & Merrill No. 30 hog, we have four of them and they are first class, I have shoved oak cord wood through them and handled it with our blowing system. Here where I am employed we have very likely the largest blowing system in the country, consisting of five double 80-in. and one single 80-in. fans, our cyclones are on top of a large fuel house, from which the fuel is fed into the furnaces with a chain conveyor and an elevator. We burn nothing but sawdust and shavings, of which we have an abundant supply. M. B. KRAMER.

ANY SYSTEM that will be of force enough to blow shavings and sawdust into the fires direct from the fan or blower is usually hard on the fire walls and boiler seams and tubes. I am at present located with a manufacturer of picture frames and moldings of all sizes and shapes. We have quite a lot of it from the factory yard and machine rooms. We have one 150-hp. and one 80-hp. boilers, both tubular. We have installed under our boilers smokeless inclined hand stokers. Our shavings and sawdust are cycloned into a dust house close and convenient enough for the fireman to reach and fire them into the fire box, alternating with coal. This shavings and sawdust house has a dust collector located on the outside to do away with excessive dust from the cyclone.

In regard to the strips, edgings and short kindling, our clean-up man cuts them with the cutoff saw not to exceed 7 ft. in length and they are readily fired by hand. Under no consideration would I attempt to blow shavings into a fire box direct from a pan or cyclone of

any type for the cold and direct blast of air on the fire-walls and boiler would soon call for a new boiler. The fire hazard would be so great that it would bring unpleasant conditions with the insurance company with the attempt to store shavings of any quantity for any length of time. GEO. E. AUSTIN.

THE PROBLEM confronting D. J. B. in regard to the proper method of handling shavings and refuse is one that has come up for consideration by many engineers and while the conditions in no two plants are the same, yet there are some points of similarity in all plants where it is desired to use shavings and refuse as fuel, either wholly or in part.

The question of blowing the shavings directly into the firebox is entirely impracticable and should not be considered for a moment; but the shavings should be discharged by the blower into the cyclone where the surplus air used to propel the shavings through the pipes is permitted to find a means of egress through the top of the cyclone without taking any of the shavings with it, the latter finding their way to the bottom of the cyclone by a rotary motion imparted to them by the blower assisted by gravity.

By the time the shavings have reached the bottom of the cyclone, they are in a position to travel only by means of gravity, as the influence of the fan is no longer present. And right here there may be introduced a suitable cutout device so that the shavings may be discharged not only into the storage bin but into the furnace as well, but the cyclone must be placed in such a position that the pipes leading to either the bin or the furnace have ample fall, not less than 45 deg. for the average refuse if dry.

The hog may be arranged to feed into the cyclone in connection with the shavings and this kind of fuel will work through the cyclone and pipes to either bin or furnace as well as shavings. While the surplus shavings and "hog feed" can be stored in the bin during periods when the supply exceeds the demands of the furnace and again handled by the fan and fed to the furnace when the demand exceeds the supply. This is not an economical method of handling refuse if used to any great extent.

It might be arranged to use refuse exclusively until the kindling is used up if the supply of the latter can be regulated somewhat by the demands of steam, after which use coal or other fuel to make up the surplus after using the small amount of shavings and dust that come from the machines during the day.

As for having a man stand at the hog and feed the fuel just as required, what is the difference whether he stands there all day shoveling in shavings from a bin, coal from a truck, or kindling into the hog, or nothing at all if the supply and demand are constant, as in case of an automatic stoker? A fireman is not an ornament like a copper air chamber or nickel-plated scoop shovel. Too many of them have that idea and they are always firemen. GEORGE H. WALLACE.

Diesel Engineers

WITH REFERENCE to the letter of C. W. R., appearing under the above caption on page 301 of the April 1 issue and the answer of John Pierce on page 375 of the May 1 issue, I should like to offer my idea as to the condition resulting when the atomizer became stopped.

As yet I have not experienced this trouble, although I may. It occurs to me that the cause of his valves melting under the heat of compression was lack of sufficient material or radiating surface to care properly for the heat resulting from a compression of 500 lb.

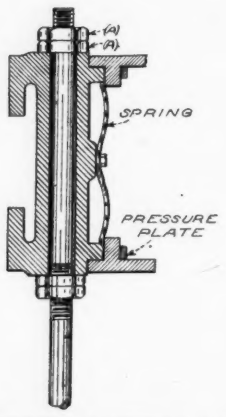
It would appear desirable to have the heat of combustion not as great or intense as that due to compression alone because of the cooling effect of the expanding charge of injection air. We all know how cold a jet of air feels when escaping from a high pressure.

In addition, the fuel has a certain amount of cooling influence because its particles are required to absorb the heat of compression before becoming ignited and by the time ignition occurs or before its completion, the piston has moved a considerable distance, thus preventing any great rise, if any, in temperature. This is my opinion and I should be glad to see further discussion of this subject, as there are no doubt others with different ideas and considerably more experienced than I, who might be able to offer other explanations.

In conclusion, allow me to state that I also have learned that frequently the troubles encountered are due more to the engineer than the engine. I believe this to be as true with other types of internal combustion engines as with the Diesels. F. C. WILLIAMS.

Engine Operating Below Speed

A SMALL HIGH-SPEED ENGINE installed to drive a fan was provided with a balanced valve. On starting, this



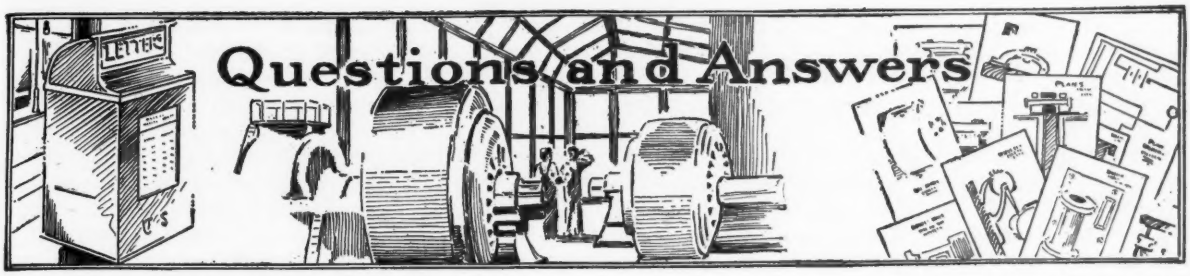
VALVE SHOWING ADJUSTING NUTS A, A

engine was found to run considerably below speed and a clicking noise was heard in the steam chest.

Removing the steam chest cover the nuts, A, A of the valve shown in the accompanying illustration, were found to be so as not to allow the valve to move on its seat. These nuts were, however, then slackened sufficiently to insert a 0.24-in. feeler between them and the end of the valve and then again tightened.

On starting, the engine came up to proper speed.

Before this change, live steam would blow into the exhaust. RECEIVER.



Firing Hawley Down-Draft Furnaces

WHAT IS the Hawley down-draft furnace? Kindly give me some hints relative to its operation.

C. D.

A. In the Hawley down-draft furnace, there are two separate grates, one above the other, the upper one being formed of parallel water tubes connected with the water space of the boiler through steel headers or drums, in such a manner as to ensure a positive circulation. Fuel is supplied to the upper grate—the lower one, formed of common bars, being fed by the half-consumed fuel falling from the upper grate.

Air for combustion enters the upper fire door which is kept open, and passes first through the bed of green fuel on the upper grate, and then over the incandescent fuel on the lower grate. A strong draft is required, due to the relatively small upper grate area and the correspondingly high rate of combustion.

Lump coal gives better results than the smaller sizes, as the latter are apt to fall through the upper grate before being even partially consumed; and when such is the case, efficient results cannot be obtained.

If carefully manipulated, this furnace, with fire-tile tubes, gives high boiler efficiency and smokeless combustion, but its overload capacity is limited. Without the fire tiling, smokeless combustion is possible only at light loads.

The theory of this furnace is, that the gases distilled from the green coal are mixed with air, ignited and burned while being passed through the underlying incandescent fuel. After the coal is coked, it is expected to drop through the grates upon the second grate. Combustion of the coke or fixed carbon is completed upon this second grate.

It can be seen that such a furnace has somewhat narrow limitations with respect to coal. If, for instance, the coal is too fine, it will fall through upon the second grate before coking is completed, and there will be smoke.

If the coal is too coarse, it will not pass through the upper grate when coking is completed, and the fireman will be compelled to help it through with a fire tool. If this is done at a time when uncoked coal is upon the upper grate, some of it will probably accompany the coked coal to the lower grate and there will be smoke.

If it is desired, at any time, to force the furnace to meet an extra demand for steam, the coal must either be burned directly upon the lower grate or the uncoked fuel upon the coking grate must be forced through upon the lower grate, in order to make room for a fresh supply of green coal.

To force a furnace of this type without producing smoke, is an exceedingly delicate operation. If an even load is carried, and the demands upon the boiler are not excessive, this furnace with careful firing will give good results as to smokelessness, otherwise there will be constant trouble. As with most other devices, a great deal depends upon the assistance of the fireman.

Hydraulic Engineering Questions

WE HAVE recently purchased the use of 500 in. of water for power purposes and desire to know the amount of horsepower this is to develop. A 6-ft. head is available and the turbines are of old style, having been installed about 40 or 50 yr. ago.

What amount of horsepower ought we to be able to realize and would digging out in front of the wheel provide us with additional power? E. L. R.

A. The miner's inch, which we assume is the measurement intended for your water supply, is the equivalent of 1½ cu. ft. of water per min.; 500 in. would, therefore, be 750 cu. ft. per min. and multiplying this by 62.4, the number of lb. per cu. ft. and by 6, the number of ft. head, gives us the ft. lb. per minute available. Dividing by 33,000 will give us the horsepower which the water can theoretically develop. This amounts to 8.53. It is not probable that you are getting more than 70 per cent efficieney. This would give you about 5.9 hp. delivered from your wheel, on the assumption that you have the water to run this at full capacity all the time.

In regard to the digging out in front of the wheel, from what you say about your setting, we would assume that this wheel is set in a flume with no draft tube, as would usually be the conditions at the time the wheel was installed. In this case, there is no advantage in digging out in front of the wheel, provided the tail water, or the overflow from the wheel, gets away freely and the water level is below the level of the discharge from the wheel.

If the tail race has filled up so that the water level below the wheel is interfering with the free escape of the water from the wheel, it will improve the performance to dig out the tail race and give free escape to the water. Just how much this would increase the horsepower we could not predict, as it all depends on the present conditions at the plant.

Temperature Entropy Diagram

ON PAGE 399 of the May 15 issue, you have started a splendid article on the application of the entropy diagram, but will you please explain why in Fig. 4 you have so distorted the card shown in Fig. 3 upside down?

There are some further questions about this that I would like to ask but do not care to do so until I receive your explanation of the procedure; and a reply would undoubtedly be of interest to others.

There is one question, however, and that is why would it not be possible to place the point 7 of the card as it is on its corresponding pressure and quality line in the entropy diagram with equally satisfactory results?

A. E. W.

A. Figure 4 is not upside down. The PV and TN diagrams are not supposed to resemble each other. To illustrate this point clearly, an adiabatic expansion on the PV diagram is very much like the expansion line on an indicator card; on the TN diagram, this expansion would be represented by a vertical line. An isothermal expansion on the PV diagram also resembles in general the expansion line on an indicator card, but on the TN diagram this expansion would be represented by a horizontal line.

In regard to why it would not be possible to place the point 7 of the card as it is on the corresponding pressure and quality line in the entropy diagram, you will notice in the temperature entropy diagram we have no pressure scale. It would, of course, be possible to place a pressure scale opposite the temperature scale; then, of course, you could place the point in the position representing its pressure and quality, the quality scale being along the line BC, which would be divided into 100 equal parts.

You will note from the table that the pressure at the point 7 is 52 and the corresponding temperature is 284 and, as stated above, it would be entirely feasible to place a pressure scale, say, to the right of the diagram and with the quality scale above, as suggested.

C. A. JOERGER.

Criticism of Indicator Card

THE INDICATOR CARDS submitted by A. G. E. in the May 15 issue, are far better than the average that one encounters and they show that outside of a late admission, there is little to criticize about them. If the engine operated at a slower speed, the admission line might conform to the ideal; but as it is, it leans slightly toward the card, which indicates that steam is not admitted to the cylinder freely enough.

The remedy is an earlier admission and the manner of securing this depends somewhat on the type of engine and the design. If the steam valves are functioned by a separate eccentric, the proper thing to do is to advance this eccentric on the shaft a small amount—say half an inch—and take another card and compare results; after all, it is the indicator that tells the story.

If the engine has but one eccentric, advancing this on the shaft will naturally advance all events. In this event, if it be a four-valve engine, it may be necessary to do a little separate adjustment on each valve in order to secure the best results. While earlier admission may be secured by reducing the steam lap, independent of any other adjustment, yet great care must be used not to reduce this too much or it will soon cause leaky valves.

The head end takes slightly more steam than the crank end and can be remedied by a slight adjustment of the cutoff.

GEORGE H. WALLACE.

I WOULD SAY to A. G. E. that the atmospheric line shows the card has been taken by a new, unstretched indicator cord and by looking at crank and head ends, without using the planimeter, the head end is doing the most work. The horsepower constant is greater on the head end than the crank end, owing to crank end having the piston rod in it, hence has less area and smaller horsepower constant; otherwise the card looks favorably good. A stretchy cord is a poor, unreliable thing to take cards with and above all don't make alterations until this is remedied.

JOHN M. LEITCH.

THESE ARE very fair cards, although unequal in area and showing late admission which is the cause of the vertical line leaning somewhat, also the steam falling down hill to cutoff, all of which is the cause of the eccentric being set back too far. A small steam pipe to engine would cause this same wire-drawing, but I would advance the eccentric first. This will increase the already sufficient compression, but this can easily be remedied by changing the exhaust rods. We take for granted this is a Corliss engine. A. G. E. did not tell us the steam pressure or number of indicator spring. The card is 3 1/16 in. long and in measuring with my Ansler planimeter I find the head end area to be 1.90 sq. in.; this, divided by the length, 3.06, gives 0.6 as the average height and 24 as the m.e.p. for a 40 spring, or 36 if a 60 spring was used, assuming the card as reproduced is actual size, while the crank end measures 1.70 sq. in., giving 22 m.e.p. if a 40-lb. spring was used, or 33 m.e.p. if a 60-lb. spring was used. The horsepower constant of this engine is 190.44 hp. if a 40-lb. spring was used, or 285.66 hp. if a 60-lb. spring was used, because the average m.e.p. is 23 for a 40 and 34½ for a 60-lb. spring. I find that the steam line of the crank end card is 3 lb. higher than that of the head end card which is not at all unusual, for in 95 cases out of 100, I have found it so. This is caused by the angularity of the connecting rod which causes the piston to move slower on leaving and approaching the crank end allowing the steam more time to attain boiler pressure. Because of this, one can easily tell which is the crank or head end by measuring from the atmospheric line. I advise A. G. E. to get rid of some back pressure if possible for the sake of economy.

A. C. WALDRON.

I WOULD SUGGEST that when cards are offered for criticism that the scale of the card be given, or better yet, the initial pressure and the boiler pressure at the throttle.

I note that his engine is a 36-in. stroke, running at 145 r.p.m., giving a piston speed of 870 ft. per min. The cards are fair average cards, but might not be applicable to an engine operating under such velocity, as there is a falling off in the admission line to the point of cutoff; but whether this is due to restricted openings admitting steam to the pistons, or whether it is due to a partially closed throttle, is hard to state unless the facts are known. Some engineers operate their machines under just enough throttle to carry the load, as a safety measure in case of accident to the governor, where racing might occur.

The terminal pressures are good, but there is an excessive amount of back pressure. A. G. E. should have stated whether or not there was a back pressure valve on the exhaust connecting to a heating system. If there

is not, the pressure is excessive and this may be due to restricted openings in the exhaust passages. However, the back pressure line is parallel with the atmospheric line, showing that the exhaust port opens in right proportion to the increased velocity of the piston as it advances towards mid-stroke.

Considering the size of this engine and its velocity, it would seem as though the compression was insufficient and there is an apparent lack of lead which is equal at both strokes. This can be corrected by advancing eccentrics and increased compression can be obtained, if it is desired, by causing the exhaust valve to close slightly earlier in the stroke.

The lack of suitable compression is liable to cause a knock near the center, due to the fact that there is insufficient pressure to cushion properly the reciprocating parts at the end of the stroke.

W. O. Moody.

There is nothing grievously wrong with the card as a whole, the few faults there are being of minor importance. The following remarks may help A. G. E. to make adjustments that will make slight improvement in the steam distribution throughout:

The lead of both head and crank end steam valves appears to be a trifle late, as shown by the departure of the lead lines from the vertical lines drawn on the accompanying figure. This may be due to the valves opening slowly rather than to lack of lead, or it may be due to the indicator piping restricting the flow of steam to the indicator. I don't believe that it is enough to bother with, especially if he knows that his engine valves have a positive amount of lead at the beginning of the stroke of the piston. It seems to be the consensus of opinion that the less lead given engine valves the better for both smooth running and economy in the use of steam.

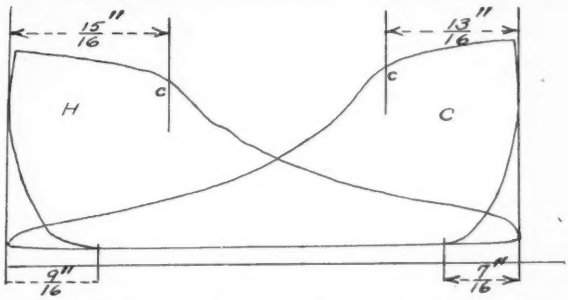
If he knows that the valves should be given more lead than they have at present, then he should make the adjustments with the valves and their connections and not with the eccentric; as the exhaust events show that to advance the eccentric (a single eccentric engine being presumed) would be to increase the compression and advance the opening for release, both of which events are about right as they are at present. If, for any reason, he must shift the eccentric to gain more lead for the steam valves, then he should re-adjust his exhaust valves to keep them as they are now. I presume the engine is a Corliss from the appearance of the diagrams, although there are other makes of engines that produce similar diagrams. The principle of valve setting and adjustment, however, is the same for all steam engines, no matter what the means for making the adjustments.

Cutoff occurs later at the head end of the cylinder than at the crank end. This may have been only for a stroke or two and at some other time during the taking of cards the late cutoff might occur at the crank end; but if the cutoff is late at the head end always, then A. G. E. can adjust his governor rods until he secures an equalized cutoff for both ends. Preferably, the cutoff should be a little later at the crank end for the m.e.p. at the crank end should be a little higher than at the head end, because the piston area at the crank end is less than at the head end—the amount the cutoff is out is shown by the lines, cc, and dimensions on the diagrams herewith.

Compression occurs earlier at the head end than it does at the crank end. This can be reduced by adjusting the head end exhaust valve, as the compression at the crank end is about right for that engine and the speed at which it is running. The falling steam lines are not due to valve setting, but to small port areas for the speed of piston attained. Possibly a slight increase of lead may make an improvement by reducing the slope of the lines; that is a common fault with many engines.

The release of steam from the cylinder at both ends is good and the exhaust passage is clear, as shown by the back pressure line being parallel with the atmospheric line. As the scale of the diagrams is not given, nor is the boiler pressure, there is no way of knowing whether the back pressure is higher than it ought to be. If the exhaust were used for a heating system at the time the diagrams were taken, then judgment would say that the back pressure is about right; but if the exhaust were not used for heating, then the back pressure may be a little higher than it ought to be, due perhaps to a long and too small exhaust pipe.

On the whole, these diagrams represent a fair condition of affairs in valve adjustment and steam distribution. The possible improvements that may be made



LINES SHOWING UNEQUAL CUTOFF AND COMPRESSION

are small, but in these times every little counts more than ever before so the effort is worth making.

Charles J. Mason.

Boiling Temperature of Lard

From what I can gather relative to lard, the melting point is 97 deg. F., the congealing point is at 81 deg. F. and the boiling point is between 575 and 600 deg. F.

Charles J. Mason.

Horizontal or Vertical Baffles?

Which are the better for use in a 150-hp. water-tube boiler of the Keeler type, horizontal or vertical baffles?

J. E. M.

A. There is much dispute as to the question of vertical vs. horizontal baffles for boilers. Some engineers prefer the vertical setting, and some the horizontal.

It seems to depend largely on the height of the boiler. If you have a high boiler, the vertical baffling will probably give the better result. If you have a low boiler, the horizontal baffling gives a better opportunity for gas travel. Especially if you have a low firebox, the use of a tile roof on the front end of the lower bank of tubes will tend to give better combustion than the vertical type.

POWER PLANT ENGINEERING

Trade-mark, Reg. U. S. Pat. Off.
(Established over 22 years.)
Formerly PRACTICAL ENGINEER
PUBLISHED THE FIRST AND FIFTEENTH OF EACH MONTH

BY THE TECHNICAL PUBLISHING CO.
537 South Dearborn Street,
CHICAGO, ILL.

New York Office, 150 Nassau St.

Notify us at once of any change of address, giving the old and the new address, so that your paper may always reach you promptly.

Copyright, 1918, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Circulation of this issue 23,700.

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Government Inspection. Are You Prepared?

The announcement coming from Washington a short time ago that plants using coal would be inspected and classified opens the door of opportunity to every engineer who has been striving with but little success to secure equipment for his plant adequate for its needs. There seems to exist considerable apprehension that the entire responsibility for the condition of the plant will fall upon the engineer in charge, that in many cases he will be expected to do the impossible, that regardless of his plant equipment his fuel consumption must not go beyond a certain limit.

While the Government is striving to have the ideal reached in the operation of power plants, the work of classification will be done by engineers who know what can be done with the equipment at hand and orders coming from them will be directed more particularly against the owner and inefficient or incompetent engineer than against those engineers who have done their duty by their plants regardless of the type of machinery, design of plant and facilities for operating it.

Can you, in the 90 days which the Government states will be given, put your plant in shape for inspection? By that is not meant that you install new equipment of the highest efficiency, if you have not already done so, but can you put the machinery which you have in the "pink" of condition. Could you demonstrate by a test that your plant cannot be run more efficiently with present equipment than is being done? If you can, your record as an operating engineer will be unquestioned.

Upon the engineer, however, in most plants falls the duty of advising the owner what equipment is needed, what type to secure, the devices needed in the way of instruments to aid materially in maintaining economy, what extensive repairs are required and in general of keeping the owner posted upon the condition of his plant whether it is 75 per cent modern and operating at 90 per cent of its highest possible efficiency, or 95 per cent modern and 75 per cent efficient.

It is a common complaint among engineers that owners are prone to look upon instruments which are solely for the purpose of aiding the operator in maintaining proper conditions, as superfluous and as giving aid without a return on the investment. Now is the time to impress upon these owners, such facts as were brought out in the series of articles, entitled "Power Plant Instruments as an Investment," which was recently published in Power Plant Engineering.

Are you prepared to answer such questions as these, with the feeling that you have done all within your power to bring the plant up to highest efficiency: What is the condition of your boiler setting? What is your average CO_2 record? How many square feet of uncovered steam piping have you? Do you exhaust to atmosphere without reclaiming any heat? What steam leaks have you? In what condition are your traps? And many others along the same line which have to do with the efficiency of the plant as a whole.

These are problems for the engineer, problems which he has met continually in his daily work. Those engineers who do not meet the requirements specified by the Government will be instructed by experts. Those

plants which are incapable of meeting the standards will be ordered to make specified improvements or close up shop.

Can there be anything more fair than this, to the engineer, to the owner or to the people of the country at large?

A Great Disaster

By Edward Mott Woolley

A GREAT disaster threatens the readers of technical papers. When the new Zone System of postal rates goes into effect in July these papers will be affected more than some other kinds of publications and this means that their readers will suffer heavily by being shut off more or less from this wonderful fund of information.

Technical papers carry a large proportion of advertising and therefore, the burden of the postal increase ranging from 50 to 900 per cent will fall very heavily on them. Now anyone who uses such papers knows that the advertising pages, while published for profit, are read for information just as much as the editorial pages. In my own case, I am continually finding wonderful funds of news and fact in the advertisements as well as in the other pages of these periodicals. If the publishers were to eliminate the advertising and print simply articles, what a vacuous magazine we would have! The advertisements reflect the whole industry represented by any given publication. In the aggregate the advertisements of all the business papers stand as the index of American industry.

I have occasion all the time to observe what great educational influence lies in the advertising pages of the technical papers. Once I happened to mention in one of my articles a type of device I had seen advertised in a class magazine. Immediately I received a letter from a man who had never heard of this invention and he was very much interested. In answering his letter I suggested that if he would read these advertisements he would get much that he would find invaluable in his business.

It goes without saying that this man was the exception, for the very existence of scores of technical papers with circulations that take in the whole country, proves that the people need them. Shopkeepers, mechanics and students depend upon these journals for their broader knowledge of the particular industry in which they are engaged.

I know of many industrial and mercantile houses where numerous papers are kept in the files and where various systems are used in giving the executives and often the mechanics and workers generally, opportunity to read them. One of these concerns, for instance, has a plan by which certain publications are passed around from man to man and each is required to return them in a specified time so that others may have them.

That the whole economic prosperity of the country will suffer by the shutting off of class periodicals is clear enough to those who fully understand their value.

Trade papers, too, are continually printing the reports of investigation of advanced thinkers in merchandising and industrial lines. There is no other medium that would carry these in detail. More often the newspapers do not even make reference to them.

The technical papers employ writers and men of broad experience to go out and get material along the lines of progressive management. I know of one paper that sent a man across the continent and back in an automobile to investigate certain merchandising experience. He stopped at scores of towns and gathered from merchants in widely separated localities a great fund of information along the line of store operation.

There are other publications that are veritable technical schools in which young men can learn, for instance, the textile business. The young druggist would be in a sad way without his trade paper in which he finds not only a never-ending flow of business-getting ideas, but technical information without which he would speedily fall behind the times. Or take the woodworker. Whether he happens to be an executive with managerial problems or an engineer with questions of plant operation, he turns to his own particular trade paper for counsel.

Thus it goes all through every line of industry. There are hundreds of technical papers. They work quietly and the general public knows little about them, but altogether they constitute one of the most powerful educational agencies.

The ill-advised postal Zone Law will make it impossible for these papers to exist in any such form as they do now. Inevitably they must be curtailed so radically that the benefits we now get from them will be largely wiped out. If you don't want this disaster to fall on you, make the fact so plain to your senators and congressmen that they will repeal this destructive Zone Law.

Write to your congressman to repeal this destructive and disastrous postal "zone" law today.

Underwater storage of bituminous coal has been found free from all disadvantages except cost, as the coal does not deteriorate nor is there chance for spontaneous combustion. Data of some storage pits are as follows: Western Electric Co., Chicago: 12 pits, each 80 by 25 by 16 ft. deep; capacity 41,000 tons. Indianapolis Light & Heat Co.: 1 pit, 300 by 100 by 28 ft. deep, 18 ft. being below ground with slope of 45 deg. to walls; bottom is 272 by 72 ft.; concrete wall 12 to 18 in. thick, reinforced with ½-in. square twisted rods; capacity 13,000 tons. Coal handled from a trestle through the middle of pit carried on piers at 15 ft. centers. Duquesne Light Co., Pittsburgh: pit of ferro-concrete 800 by 150 by 25.5 ft. deep with 45-deg. sides, capacity 100,000 tons. Coal handled from tracks at each side of the pit by locomotive cranes.

Illinois State Civil Service Commission announces examinations for June 22, among which are the following: Architectural draftsman, salary $75 to $150 a month; marine engineer, salary $75 to $100 a month; roller operator, salary $75 to $125 a month.

Address requests for appplication blanks and circulars to the State Civil Service Commission, Springfield, Ill.

Edward Clarence Meier

ENGINEERS, friends of the Heine Safety Boiler Co., and all who are interested in our present shipbuilding program were startled on May 7, by news dispatches regarding the sudden taking away of E. C. Meier, president of the large boiler concern.

Mr. Meier lift his home in Phoenixville, Pa., on the morning of May 7, apparently in good health, to attend the meeting of the District Production Division of the Emergency Fleet Corporation, which was held in the afternoon at the Racquet Club, Philadelphia. Over 200 heads of industries, engaged at turning out ships and ship equipment for the government were in attendance. The meeting was for the purpose of speeding up production. About 3 o'clock, Mr. Meier made a short address, giving some of his views regarding the speeding up on the construction of boilers. Shortly after resuming his seat he became ill and died almost immediately.

Edward Clarence Meier, was the son of the late Col. Edward D. and Clara Giesecke Meier, and was born at Wyandotte, Kan., April 28, 1870. Col. E. D. Meier, his father, achieved distinction as founder of the Heine Safety Boiler Co., president of the American Society of Mechanical Engineers and the leading spirit in the development of the present A. S. M. E. Boiler Code, which is now being rapidly adopted by the many states of our union.

Edward Clarence Meier received his education in the public schools of St. Louis and the St. Louis Manual Training School. As a boy, starting when only 11 yr. old, he worked during the vacation periods in Richard Garstang's boiler shop at St. Louis, where Heine boilers were originally made. After completing his school course he started to work for the Heine Boiler Co., which was organized by his father in 1884.

Mr. Meier worked in all departments of the company and was thoroughly familiar with the construction of boilers. He was entrusted with installing the Heine Boiler Co.'s exhibit at the World's Fair, Chicago, and when the fair closed he had supervision of dismantling the boilers and the shipping of them to San Francisco, where they were installed at the mid-winter fair in 1894. While at this fair, Mr. Meier first met Miss Charlotte Isabelle Douglas, his widowed wife. Mr. Meier established offices in Philadelphia in 1895. From this office he exercised general supervision of the eastern shops, where Heine boilers were built. In 1899 the company purchased the Denithorne Bridge Works, which formed the nucleus for the present establishment at Phoenixville.

The deceased was a director of the Heine Safety Boiler Co. for many years and before becoming president had served for some years as vice-president. Upon the death of his father, Col. E. D. Meier, which occurred in 1916, Mr. Meier was elected president.

During the past year, E. C. Meier had been very active in designing a boiler suitable for marine work and it was through his intimate knowledge of boilers that he was influential in securing government contracts which are now taxing the Phoenixville shop to 100 per cent capacity.

During his busy career as a manufacturer, Mr. Meier also gave considerable of his time to the upbuilding of the community and to the local government of Phoenixville.

In the death of Mr. Meier, the nation loses a progressive citizen and the workingmen lose a friend who spared no effort or expense in attending to their comforts.

Mr. Meier is survived by his wife and the following children: Edward D., Theodore H., Charlotte Alice and Clarence C. He is also survived by two brothers, C. R. D., of St. Louis and Theodore G., of San Francisco and three sisters, Miss Mary Alice Meier, of Washington, Mrs. Elizabeth P. Schevill, of New York and Mrs. Clara E. Schevill, of Chicago, Ill.

Bituminous Coal Prices Reduced

TEN CENTS a short ton has been stricken from the mine price of all bituminous coal in the United States by order of Fuel Administrator H. A. Garfield. The new price took effect at seven o'clock Saturday morning, May 25, and represents an average reduction of nearly five per cent. The order reads as follows:

"The United States Fuel Administrator, acting under authority of an executive order of the President, dated Aug. 23, 1917, appointing said administrator and of subsequent executive orders and in furtherance of said orders and of the Act of Congress therein referred to and approved Aug. 10, 1917,

"Hereby orders and directs that all prices for bituminous coal f.o.b. mines in the coal producing districts throughout the United States fixed by the said executive order of the President, dated Aug. 21, 1917, and subsequent orders of the United States Fuel Administrator and in effect at 7 a. m. on the 25th day of May, 1918, shall be and the same hereby are reduced as to all shipments made after 7 a. m. on the 25th day of May, 1918, by the sum of 10 c. for each net ton of 2000 lb.

"This order shall in no way affect the increase contained in the executive order of the President, dated Oct. 27, 1917, adding the sum of 45 c. to the prices fixed for bituminous coal under the terms and provisions set forth in said last mentioned order."

The reduction will mean an annual saving to consumers of a sum estimated by the Fuel Administration at $60,000,000. The President has directed that the railroads pay the government price for coal. The increased cost of railroad fuel thereby occasioned is also estimated at $60,000,000 a year. The reduction of 10 c. per ton on all coal will, however, reduce the net increased cost to the railroads from $60,000,000 to $45,000,000 a year. Under the President's plan, the railroads will furnish cars to all coal mines alike, without discrimination, except as dictated by the prior requirements of the railroads for operating purposes and the needs of domestic consumers and of the war.

Under the present war demands, the maximum output of every mine working at full time would still be insufficient to meet the country's coal needs. The principle of equal car supply has accordingly been adopted so as to make for as steady an operation as possible of all properties and for continuous employment of men, thus making for maximum output.

The introduction of the principle of even car supply will reduce the general average overhead of mine opera-

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

POWER PLANT ENGINEERING

SQUARE FEET OF RADIATION REQUIRED FOR THE CUBIC CONTENTS OF ROOMS

S—steam, V—vapor, HW—hot water. Add 10 per cent in rooms on windward side of building. Based on 70 deg. in zero weather.

Cubic Contents	1 Change of Air per Hour			1½ Changes of Air per Hour			2 Changes of Air per Hour		
	S	V	HW	S	V	HW	S	V	HW
350	2	2	3	3	4	5	4	5	6
400	2	3	4	3	4	6	4	5	8
450	3	4	4	4	5	7	6	7	8
500	3	4	5	4	5	7	6	7	9
550	3	4	5	5	6	8	6	8	10
600	4	5	6	6	7	8	8	10	11
700	4	5	6	6	7	10	8	10	13
800	5	6	7	7	9	11	10	12	15
900	5	6	8	8	10	12	10	13	16
1000	6	7	9	9	11	13	12	14	18
1200	7	8	11	10	12	17	14	17	22
1400	8	10	13	12	14	19	16	19	26
1600	9	11	15	13	16	22	18	22	29
1800	10	12	16	15	18	25	20	24	31
2000	12	14	18	17	20	27	24	29	37
2200	13	16	20	19	23	30	26	31	40
2400	14	17	22	21	25	33	28	34	44
2600	15	18	24	23	28	35	30	36	47
2800	16	19	26	24	29	38	32	38	51
3000	17	21	28	26	31	41	34	41	55
3200	19	23	29	28	34	44	38	46	59
3400	20	24	31	30	36	46	40	48	62
3600	21	25	33	31	37	49	42	50	66
3800	22	26	35	33	40	52	44	53	70
4000	23	28	37	35	42	55	46	55	73
4200	24	29	39	37	44	58	49	59	77
4400	26	31	40	38	46	61	51	61	79
4600	27	32	42	40	48	63	53	64	84
4800	28	34	44	42	50	66	56	67	88
5000	29	35	46	44	53	69	58	70	92

POWER PLANT ENGINEERING

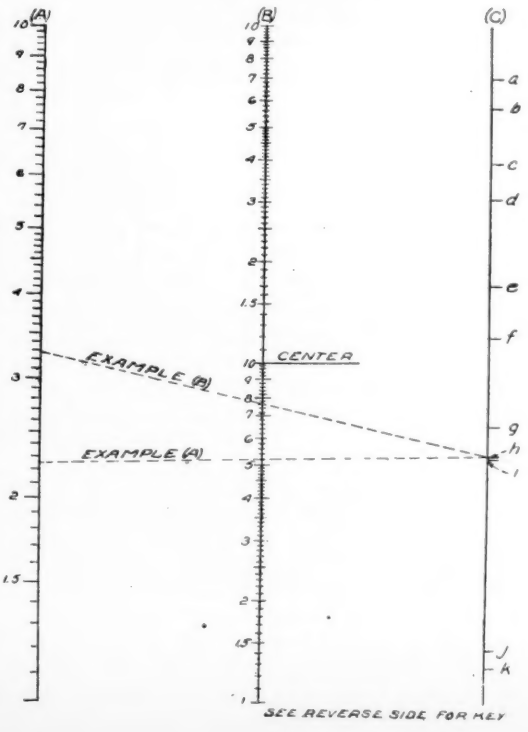
SQUARE FEET OF RADIATION FOR GLASS SURFACE

S—steam, V—vapor, HW—hot water. Add 10 per cent in rooms on windward side of building. Based on 70 deg. in zero weather.

Sq. Ft. of Glass Surface	Single Window			Double Window		
	S	V	HW	S	V	HW
6	2	2	3	1	1	1
7	2	2	3	1	1	2
8	2	3	4	1	1	2
9	3	3	4	1	2	2
10	3	4	5	2	2	3
12	4	4	6	2	2	3
14	4	5	7	2	2	3
16	5	5	8	2	3	4
18	5	6	9	3	3	4
20	6	7	10	3	3	5
22	7	8	10	3	4	5
24	7	9	11	4	4	6
26	8	9	12	4	5	6
28	8	10	13	4	5	7
30	9	11	14	5	6	7
32	10	12	15	5	6	8
34	10	12	16	5	6	8
36	11	13	17	6	7	9
38	12	14	18	6	7	9
40	12	14	19	6	7	10
42	13	16	20	6	8	10
44	13	16	21	7	8	10
46	14	17	22	7	9	11
48	15	18	23	7	9	12
50	15	18	24	8	9	12
52	16	19	25	8	10	12
54	16	19	26	8	10	13
56	17	20	27	9	11	13
58	18	21	28	9	11	14
60	18	22	29	9	12	14

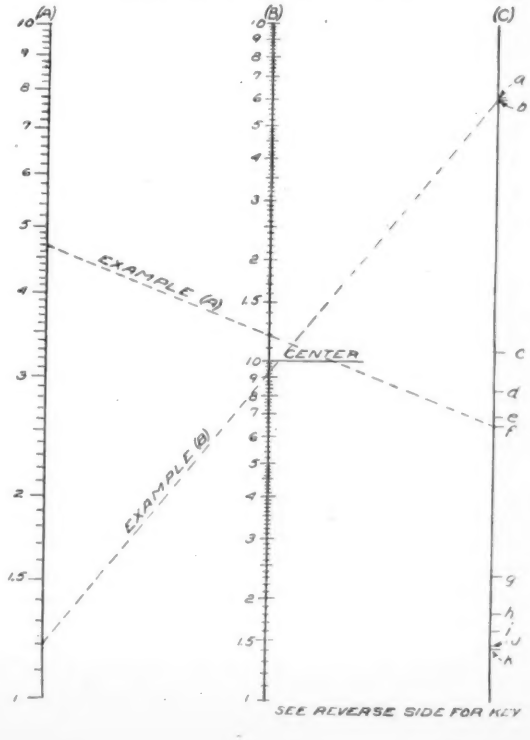
POWER PLANT ENGINEERING

WATER CONVERSION CHART



POWER PLANT ENGINEERING

ELECTRICAL CONVERSION CHART



HEATING SURFACE OF CAST-IRON RADIATORS, SQ. FT.

Number of sections	Length 2.5 in. per section	Height 13 in. Width 2 Col.	Height 18 in. Width 3 Col.	Height 20 in. Width 1 Col.	Height 20 in. Width 2 Col.	Height 20 in. Width 4 Col.	Height 23 in. Width 1 Col.	Height 23 in. Width 2 Col.	Height 23 in. Width 3 Col.	Height 23 in. Width 4 Col.	Height 26 in. Width 1 Col.	Height 26 in. Width 2 Col.	Height 26 in. Width 3 Col.	Height 26 in. Width 4 Col.
2	5	3-1/3	4-1/3	3-1/3	4	8	4-2/3	6	9	9-1/3	4	8-1/3	7-1/3	10-2/3
3	7.5	4-1/2	6-3/4	4-1/2	6	12	6-1/2	9	13-1/2	13-1/2	6	12	11-1/4	16-1/3
4	10	6	9	6-1/2	8	16	8-2/3	12	18	18	8	16-2/3	15	21-1/3
5	12.5	7-1/2	11-1/4	7-1/2	10	20	10-1/3	15	22-1/2	22-1/2	10	20-2/3	18-3/4	26-2/3
6	15	9	13-1/2	9	12	24	11-2/3	18	27	27	12	25	22-1/2	32
7	17.5	10	15-3/4	10-1/2	14	28	13-1/3	21	31-1/2	31-1/2	14	29-1/3	26-1/4	37-1/3
8	20	11-1/2	18	12	16	32	15	24	36	36	16	33-1/3	30	42-2/3
9	22.5	13	20-1/4	13-1/2	18	36	16-2/3	27	40-1/2	40-1/2	18	37-1/2	33-3/4	48
10	25	14-1/2	22-1/2	15	20	40	18-1/3	30	45	45	20	41-2/3	37-1/2	53-1/3
11	27.5	15-1/2	24-3/4	16-1/2	22	44	20	33	49-1/2	49-1/2	22	45-5/6	41-1/4	58-2/3
12	30	16-1/2	27	18	24	48	21-2/3	36	54	54	24	50	45	64
13	32.5	18	29-1/4	19-1/2	26	52	23-1/3	39	58-1/2	58-1/2	26	54-1/6	48-3/4	69-1/3
14	35	19	31-1/2	21	28	56	25	42	63	63	28	58-1/3	52-1/2	74-2/3
15	37.5	20	33-3/4	22-1/2	30	60	26-2/3	45	67-1/2	67-1/2	30	62-1/2	56-1/4	80
16	40	21-1/2	36	24	32	64	28-1/3	48	72	72	32	66-2/3	60	85-1/3
17	42.5	23	38-1/4	25-1/2	34	68	30	51	76-1/2	76-1/2	34	70-5/6	63-3/4	90-2/3
18	45	24	40-1/2	27	36	72	31-2/3	54	81	81	36	75	67-1/2	96
19	47.5	25	42-3/4	28-1/2	38	76	33-1/3	57	85-1/2	85-1/2	38	79-1/6	71-1/4	101-1/3
20	50	26-1/2	45	30	40	80	35	60	90	90	40	83-1/3	75	106-2/3
21	52.5	28	47-1/4	31-1/2	42	84	36-2/3	63	94-1/2	94-1/2	42	87-1/2	78-3/4	112
22	55	29	49-1/2	33	44	88	38-1/3	66	99	99	44	91-2/3	82-1/2	117-1/3
23	57.5	30	51-3/4	34-1/2	46	92	40	69	103-1/2	103-1/2	46	95-5/6	86-1/4	122-2/3
24	60	31-1/2	54	36	48	96	41-2/3	72	108	108	48	100	90	128

Number of sections	Length 2.5 in. per section	Height 32 in. Width 1 Col.	Height 32 in. Width 2 Col.	Height 32 in. Width 3 Col.	Height 32 in. Width 4 Col.	Height 38 in. Width 1 Col.	Height 38 in. Width 2 Col.	Height 38 in. Width 3 Col.	Height 38 in. Width 4 Col.	Height 45 in. Width 2 Col.	Height 45 in. Width 3 Col.
2	5	5-1/2	6-2/3	9	13-1/3	6	8	12	18	10	16
3	7.5	8-1/2	10-1/2	13-1/2	20-2/3	9	12	18	27	15	24
4	10	10-1/2	13-1/3	18	26-2/3	12	16	24	36	20	32
5	12.5	12-1/2	16-2/3	22-1/2	33-1/3	15	20	30	45	25	40
6	15	15	20	27	40	18	24	36	54	30	48
7	17.5	17-1/2	23-1/3	31-1/2	46-2/3	21	28	42	63	35	56
8	20	20	26-2/3	36	53-1/3	24	32	48	72	40	64
9	22.5	22-1/2	30	40-1/2	60	27	36	54	81	45	72
10	25	25	33-1/3	45	66-2/3	30	40	60	90	50	80
11	27.5	27-1/2	36-2/3	49-1/2	73-1/3	33	44	66	99	55	88
12	30	30	40	54	80	36	48	72	108	60	96
13	32.5	32-1/2	43-1/3	58-1/2	86-2/3	39	52	78	117	65	104
14	35	35	46-2/3	63	93-1/3	42	56	84	126	70	112
15	37.5	37-1/2	50	67-1/2	100	45	60	90	135	75	120
16	40	40	53-1/3	72	106-2/3	48	64	96	144	80	128
17	42.5	42-1/2	56-2/3	76-1/2	113-1/3	51	68	102	153	85	136
18	45	45	60	81	120	54	72	108	162	90	144
19	47.5	47-1/2	63-1/3	85-1/2	126-2/3	57	76	114	171	95	152
20	50	50	66-2/3	90	133-1/3	60	80	120	180	100	160
21	52.5	52-1/2	70	94-1/2	140	63	84	126	189	105	168
22	55	55	73-1/3	99	146-2/3	66	88	132	198	110	176
23	57.5	57-1/2	76-2/3	103-1/2	153-1/3	69	92	138	207	115	184
24	60	60	80	108	160	72	96	144	216	120	192

SQUARE FEET OF RADIATION FOR EXPOSED WALL SURFACE

S—steam, V—vapor, HW—hot water. Add 10 per cent in rooms on windward side of building. Based on 70 deg. in zero weather.

Sq. Ft. Exposed Wall	12-in. Brick Wall, Good Frame Const. or Ceiling with Small Air Space			16-in. Brick Wall			20-in. Brick Wall			Poor Frame Constr.		
	S	V	HW	S	V	HW	S	V	HW	S	V	HW
10	1	1	1	1	1	1	1	1	1	2	2	2
20	2	2	3	2	2	2	1	1	2	4	5	6
30	3	4	4	3	3	4	2	2	3	6	7	8
40	4	5	6	3	4	5	3	4	4	8	10	12
50	5	6	7	4	5	6	3	4	5	10	12	14
60	6	7	9	5	6	7	4	5	6	12	14	18
70	7	9	10	5	6	8	5	6	7	13	16	20
80	7	9	13	6	7	9	6	7	8	14	17	24
90	8	10	13	7	8	11	6	7	9	16	19	26
100	9	11	15	8	10	12	7	8	10	18	22	30
110	10	12	16	8	10	13	7	8	11	20	24	32
120	11	13	18	9	11	14	8	10	12	22	26	36
130	12	14	19	10	12	15	9	11	14	24	29	38
140	13	16	21	10	12	16	9	11	15	26	31	42
150	14	17	22	11	13	17	10	12	16	28	34	44
160	15	18	24	12	14	19	11	13	17	30	36	48
170	16	19	25	13	16	20	11	13	18	32	38	50
180	17	21	26	14	17	21	12	14	18	34	41	52
190	18	22	28	15	18	25	13	16	19	36	43	56
200	19	23	29	16	19	24	14	17	21	38	46	58
220	20	24	32	17	20	26	14	17	23	40	48	64
240	22	26	35	18	22	29	16	19	25	44	53	70
260	24	29	38	20	24	31	17	20	26	48	58	76
280	26	31	41	21	29	33	18	22	29	52	62	82
300	28	34	44	23	28	35	20	24	31	56	67	88
320	30	36	47	24	29	38	21	25	33	60	72	92
340	32	38	50	26	31	40	23	28	35	64	75	100
360	33	40	53	27	32	42	24	29	38	66	79	106
380	35	42	56	29	35	45	25	30	40	70	84	112
400	37	44	59	31	37	48	27	32	42	74	89	118

KEY TO ELECTRICAL CHART

Scale A	Scale B	Scale C	To locate decimal* Below Center	To locate decimal* Above Center
Circular Mils	Square Mils	a	−1	0
Square Inches	Circular Mils	i	+6	+7
British Thermal Units	Foot-Pounds	b	+2	+3
British Thermal Units	Watt-Hours	d	−1	0
Kilowatt-Hours	Foot-Pounds	e	+6	+7
Kilowatt-Hours	Horsepower Hours	h	0	+1
Ohms per Cir. Mil-Ft.	Ohms per Sq. Mil-Ft.	a	−1	0
Ohms per Cu. In.	Ohms per Cir.Mil-Ft.	g	+7	+8
Ohms per Cu. In.	Ohms per Sq. Mil-Ft.	k	+7	+8
Amp. per Sq. In.	Amps. per Cir. In.	m	−1	0
B.t.u.per Sq.Ft.per Min.	Watts per Sq. In.	j	−1	0
Horsepower	Foot Pounds per Min.	c	+4	+5
Horsepower	B.t.u. per Hour	f	+3	+4

*The number of digits to the left of the decimal point in Scale B is more or less than that in Scale A by the amount shown in these two columns. The scales are read similarly to those on a slide rule, i.e., the numbered divisions represent the first significant figure, the intermediate unnumbered divisions, the second figure, and the third figure must be interpolated.

Examples: (A) The number of foot-pounds represented by 12,000 B.t.u. is 9,300,000. (B) 12,000 B.t.u. per hour = 4.68 hp. per hour.

KEY TO WATER CHART

Scale A	Scale B	Scale C	To locate decimal* Below Center	To locate decimal* Above Center
Gallons	Cu. in.	h	+2	+3
Cu. Ft	Gallons	b	0	+1
Cu. Ft	Lb Weight	c	+1	+2
Gallons	Lb. Weight	a	+1	+2
Ft. Head	Lb. pres. per sq. in.	i	0	+1
In of Mercury	Ft. Head	k	0	+1
Ft. Head	Hp. to raise 100 g.p.m.	g	−2	−1
British Gal.	U. S. Gal.	j	0	+1
Boiler Hp.	Lb.per Hr.	f	+1	+2
Boiler Hp.	Gal. per Hr.	e	0	+1
Boiler Hp.	Cu.Ft.per Hr. at 62 deg.	d	−1	0

*The number of digits to the left of the decimal point in Scale B is more or less than that in Scale A by the amount shown in these two columns. The scales are read similarly to those on a slide rule, i.e., the numbered divisions represent the first significant figure, the intermediate unnumbered divisions, the second figure, and the third figure must be interpolated.

Examples: (A) The number of cubic inches in 2.25 gal. is 520. (B) The number of gallons in 7600 cu. in. is 32.8.

tion, thereby justifying the administration in putting out a price reduction order. It is understood that the mine prices thus fixed will remain undisturbed until the United States Fuel Administrator has before him the cost returns for the 12 mo. ending Aug. 31, 1918. The returns thus far are being carefully studied by Fuel Administration accountants and engineers with a view to making the utmost saving to the public that is consistent with a maximum production of coal.

The order will have no effect on the price of anthracite coal, which forms the bulk of the domestic consumption fuel in the eastern part of the country.

Consumers of bituminous coal who have already entered their orders for the year's coal supply, but whose coal has not yet been delivered, will, of course, receive their supplies at the reduced price. The new price applies to all bituminous coal which left the mines after 7 a. m., May 25, no matter how long the order for the delivery of the coal has been standing.

Coal delivered after 7 a. m., May 25, under contracts which have been entered into since Dec. 29, 1917, will be billed at the new price. Under the regulation of the Fuel Administration all such contracts call for the delivery of coal at the government price effective at the time of delivery.

Books and Catalogs

THE MORE GENERAL storage of coal during the spring and summer months is coming to be recognized as the only practical means of avoiding a coal shortage during the winter. Many corporations and individuals will this year undertake, for the first time, to store large quantities of coal.

The storage of bituminous coal presents certain difficulties because of its tendency toward spontaneous combustion with its attendant dangers and losses. The methods to be employed in avoiding spontaneous combustion have not generally been well understood and those which have seemed successful in some cases have failed in others.

The Engineering Experiment Station of the University of Illinois has just completed a study of the problems involved in coal storage and has published the results in a 200-page illustrated book designated as Circular No. 6, "Storage of Bituminous Coal." The study was made under the direction of H. H. Stoek, Professor of Mining Engineering. The reasons and advantages of storing coal are given, the kinds and sizes of coal which may be safely stored are described, and the many factors entering into successful storage are discussed.

Copies of Circular No. 6 may be had by addressing the Engineering Experiment Station, Urbana, Ill. The price is 40 cents per copy.

TYCOS MINERAL OIL TABLES, compiled and edited by E. N. Hurlburt; 204 pages; Rochester, N. Y., 1918; price, $1.

Tycos Mineral Oil Tables is the title of an exceedingly handy and valuable little hand book of authoritative information for those connected with the testing and refining of mineral oils. It is published by the Taylor Instrument Companies and, while many of the tables embodied within this book have been obtained from reliable sources, the majority have been copied from circulars of the Bureau of Standards. The 30 and more tables given, cover temperature corrections for gravity readings, corresponding gravity and weight, and similar testing data; also for steam and refrigeration plant operation, conversion of weights, measures and moneys, etc.

A CIRCULAR relating to Rhoads leather belt was lately received from J. E. Rhoads & Sons, 12 N. Third St., Philadelphia.

FANS AND BLOWERS Condensed Catalog was lately received from Ilg Electric Ventilating Co., Whiting and Wells Sts., Chicago.

SILENT CHAIN Book No. 312, The Efficient Drive for Machine Tools, is being sent out by Link-Belt Co., 39th St. and Stewart Ave., Chicago.

SMOOTH-ON Mfg. Co.'s new instruction book, 16th edition, contains 144 pages, showing by illustration how the different Smooth-On iron cements are used for repairing purposes. The company will be pleased to mail a copy to any reader sending his name and address to Smooth-On Mfg. Co., Jersey City, N. J.

A LEAFLET describing in detail the construction and contents of an outfit of fan testing instruments, developed to conform with the requirements of reliability and convenience in handling and carrying, including the A. B. Co. pitot tube, has just been received from American Blower Co., Detroit, Mich.

SWARTWOUT feed-water heaters and purifiers are described in Form 111 of The Ohio Blower Co., Cleveland, O. This leaflet illustrates two styles, one designed for all kinds of service to which an open or direct type heater may be subjected, the other fitted for service in factories and power plants exhausting into the atmosphere direct.

FEATURES OF the Bigelow-Hornsby water-tube boiler that meet the requirements of modern power plant practice are discussed in a recent publication of the Bigelow Co., New Haven, Conn. This book also contains views illustrating the use of these boilers by various companies, and superheated steam, saturated steam pressure, and other tables.

WELLS SELF-OPENING DIES are described in a catalog recently issued by the Greenfield Tap &Die Corporation, of Greenfield, Mass. These dies are made for attachment to machine lathes, drill presses, and similar machines and the catalog illustrates how this is done and points out the advantages of the self-opening feature, giving cross-sectional views illustrating the construction simplicity of operation.

A NEW CATALOG on the Riley Underfeed Stoker is being sent out by Sanford Riley Stoker Co., Ltd., Worcester, Mass. This book discusses the construction features and the relation of the live grate surface to high efficiency and capacity, also containing installation information and engineering data which will be found helpful in planning installations of stokers under widely varying conditions.

SIGNBOARD SECTION

Quick Action Opportunities

CLASSIFIED RATES

Advertisements in the Signboard Section which come under the classifications "Position Wanted," "Help Wanted," "Salesmen and Agencies," "Patents and Patent Attorneys" and "Technical Books" will be set in type as shown below and published at the rate of

30 cents a line

each insertion, 6 words to a line; minimum sold, 4 lines.

First three words of each advertisement will be set in capital letters.

For advertising rates under other headings in this section, see column at left.

DISPLAY RATES

Advertisements in Signboard Section which come under the classifications "Equipment for Sale," "Equipment Wanted," "Educational and Instruction" and "Miscellaneous" are set in display space of the following sizes and at these rates:

1 in.	$ 4.00	4 in.	$15.50
2 in.	7.90	1 col. (8½ in.)	30.40
3 in.	11.70	2 col. (17 in.)	60.00

Not less than one inch or more than two columns will be sold in these classifications.

For advertising rates under other headings in this section, see column at right.

POSITIONS WANTED

POSITION WANTED—By master mechanic familiar with gas and steam engines, boilers and electrical machinery; capable of taking complete charge of mechanical end of large factory; 17 yrs'. experience. Age 37 yrs. Sober and in perfect health. At present employed as master mechanic of factory. Desires change on account of not liking the East and will consider only the West. Address Box 523, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 6-15-1

POSITION WANTED—As engineer in small plant; 10 yrs'. experience with Corliss and high speed engines. Familiar with d.c. generators and gasoline engines. Age 34. Married. Strictly sober and good repair man. Address F. H. Daton, 2823 Calumet Ave., Chicago, Ill. 6-15-1

POSITION WANTED—As chief engineer, 13 years' experience with Corliss and high-speed engines, electrical and refrigerating machinery. Sober and reliable. Best of references. Address Box 518, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 6-15-1

POSITION WANTED—To take charge of plant as superintendent. A1 electrician. Salary $150. For further particulars write Box 520, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 5-15-2

POSITION WANTED—By a first class man, aged 35, married, strictly sober, reliable and energetic. For the past 7 years superintendent of water, light and power plants, capable of doing any kind of work in steam or electrical engineering, meter repairing or testing, line work or inside wiring. Especially capable of managing water and light plant properties. Prefer a field where there is a chance of advancement. Address Box 522, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 6-15-1

POSITION WANTED—As oiler or assistant engineer in a power plant around New York City; 1 yr. experience as student and assistant to engineer. A. J. Benora, 38 Park Hill Ave., Yonkers, N. Y. 6-15-1

POSITION WANTED—As manager or superintendent of small plant or chief engineer in large plant. Age 29. Ten years' experience. A1 references. G. H. R., 425 Mapleton Ave., Boulder, Colo. 6-15-1

POSITION WANTED—Would like to represent some engineering specialty or electrical goods. Have display room three blocks from mill district. Will take agency on commission basis. Address H. Rookstool, 2321 N. Sixth St., Philadelphia, Pa. 6-15-1

POSITION WANTED—As superintendent of electric light plant. Twelve years' experience. Familiar with steam and oil engines, d.c. and a.c. machinery, line maintenance, etc. Address Box 526, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 6-15-1

HELP WANTED

WANTED—Central Station engineer for Indiana plant. Two, 250-hp. water tube boilers, two tandem compound engines. Position open at once. State salary expected. Address Box 524, Power Plant Engineer, 537 S. Dearborn St., Chicago, Ill. 6-15-3

WANTED—Master mechanic for large power plant; experienced in repairs and maintenance of large turbo-generators and boilers. Reply, giving full details to Box 525, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 6-15-1

WANTED—A competent refrigerating engineer in Western Pennsylvania. Must be familiar with raw water and ice making system and electric machinery. State salary wanted. Address Box 505, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf

BOILER HOUSE EFFICIENCY ENGINEER—Large pulp and paper company in Canada, with several mills, wants the services of a boiler-house and steam-plant efficiency engineer. Apply to H-21, stating age, experience, married or single, salary expected and send copies of references, which will be treated confidently. Address Box 527, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. 6-15-3

SALESMEN AND AGENCIES

WANTED—Agents on commission to sell our shaking grates. We will install grates on trial to put it to test at our expense with any grate made. Address Armstrong Mfg. Co., Springfield, O. tf

WANTED—Agents handling engine and boiler room specialties in every section for side line paying large commissions. Give experience, line carried and territory covered. Box 381, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill. tf

PATENTS AND PATENT ATTORNEYS

PATENTS THAT PROTECT AND PAY—Advice and books free. High references. Best results. Promptness assured. Send sketch or model for search. WATSON E. COLEMAN, Patent Lawyer, 624 F St., N. W., Washington, D. C. tf

PATENTS—C. L. Parker, Attorney-at-Law and Solicitor of Patents. Patents secured promptly and with special regard to the legal protection of the invention. Handbook for inventors sent upon request. Washington, D. C. tf

PATENTS—H. W. T. Jenner, Patent Attorney and Mechanical Expert, 606 F St., Washington, D. C. Established 1883. I make a free examination and report if a patent can be had and the exact costs. Send for full information. tf

A. P. CONNOR, Consulting Electrical and Mechanical Engineer, Attorney-at-Law and Solicitor of Patents and Trade-Marks. Results guaranteed. 121 Carroll St., S. E., Washington, D. C. tf

PATENTABLE IDEAS WANTED—Send for three free books. R. B. Owen, 28 Owen Bldg., Washington, D. C. tf

TECHNICAL BOOKS

FREE ENGINEER BOOKS and power plant tools and specialties, for securing new subscribers for Power Plant Engineering. A dandy chance for the engineer with a little spare time to get some fine premiums. Send for free descriptive circular and terms. Subscription Department, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill.

EQUIPMENT WANTED

WANTED

MARINE BOILERS

We will pay cash awards for information that leads to a purchase by us of marine boilers of from 75 hp. to 250 hp.

THE PITTSBURG BOILER & MACHINE CO.
Pittsburg, Kan. tf.

EDUCATIONAL AND INSTRUCTION

FREE ENGINEER BOOKS and power plant tools and specialties, for securing new subscribers for Power Plant Engineering. A dandy chance for the engineer with a little spare time to get some fine premiums. Send for free descriptive circular and terms. Subscription Department, Power Plant Engineering, 537 S. Dearborn St., Chicago, Ill.

MISCELLANEOUS

FACTORY MANAGERS, ENGINEERS AND OWNERS—Coal is high and scarce. Let us tell you how to conserve it and utilize your exhaust steam for heating and drying purposes. Address Monash Engineering Co., 1413 W. Jackson Boulevard, Chicago, Ill.

SIGNBOARD SECTION

Quick Action Opportunities

EQUIPMENT FOR SALE

For Sale—STEAM ENGINES

1 Center Crank (vertical)..... 15 hp.
1 Wright (vertical) ..... 30 hp.
1 Otto (gasoline) ..... 30 hp.
1 Armington & Sims ..... 75 hp.
1 Ide Automatic ..... 90 hp.
1 Harrisburg .....100 hp.
1 Atlas .....100 hp.
1 Straight-line .....150 hp.
1 Corliss .....225 hp.

Address
RIVER SPINNING COMPANY
Slater Trust Building,
Pawtucket, R. I.

600 H. P. Corliss Engine

Heavy Duty Cross Compound
Immediate Shipment

One 17x32x42 cross compound, rolling mill type, Filer & Stowell Corliss Engine for 160-lb. gage steam pressure, suitable for either condensing or non-condensing operating. Normal rating 500 to 600 I.H.P. at 100 R.P.M. Complete with 13½-ft. dia., 54-in. face, split double-arm belt wheel.

Engine is complete with gravity oiling system, throttle, steam separator, steam and exhaust piping and gage board. One 47-in. extra heavy double leather belt approximately 80 ft. long, made endless.

One 60-in. diam. by 52-in. face extra heavy main driven pulley. One extra heavy main line shaft with extra heavy adjustable drop hangers approximately 90 ft. long, shaft diameters, 6 in. to 4 in.

Eleven extra heavy wood split pulleys for line shaft.

One extra heavy cast iron pulley for line shaft.

Equipment has had best of care and is in first class operating condition.

Shipment immediately.

Further details upon application.

Also—Boilers, stokers, feed pumps, service pumps to equip complete power plant.

We also have a full line of NEW GENERAL ELECTRIC MOTORS for immedite shipment. Quotations furnished promptly on receipt of inquiry.

KIRCHNER-PURCELL COMPANY
423 Dime Bank Building, Detroit, Mich.

For Sale—THREE EAGLE ENGINES

One 14x18 in., one 12x16 in., one 9x11 in.; all fully equipped with oil cups, sight feed lubricators, Pickering governors and in good operative condition. One 150-hp. Hoppes feed water heater, one 4-in. separator.

CRAWFORDSVILLE SHALE BRICK CO.
Crawfordsville, Ind.

FOR SALE
250 h. p. Corliss Engine

First Class Shape. May be inspected at our Eagle Lake, Texas, plant, or full description will be sent on request.

INTERNATIONAL RICE MILLS CO.
Memphis, Tenn.

Harris Brothers Co.

Chicago

Offer from Stock:

300 H. P. WICKES BOILERS

3—Wickes Bros. vertical boilers, pressure type, quadruple riveted, butt strapped, equipped with Murphy stokers and all breechings connections. Hartford Inspection—151 lbs. pressure. These boilers are located at Detroit, Mich., and shipment can be made at once.

400 H. P. WATER TUBE BOILERS

2—400-H.P. Atlas water tube type, 4-in. tubes, complete with fronts and castings; 150 lbs. pressure. Hartford inspection.

1—400-H.P. Kennicott horizontal type, complete with castings and fittings.

MARINE TYPE

2—150-H.P. Morrison type boiler, 150 lbs. pressure.

LARGE PUMPS

3—16x10¼x14-in. Knowles outside packed.

2—7½x5x10-in. Warren.

1—14x8½x10-in. Worthington.

1—16x10¼x10-in. Worthington.

1—16x28x15½x30-in. Wilson Snyder Duplex Pump, with 10x14x18-in. jet condenser.

1—18x29x16½x18-in. Laidlow-Dunn & Gordon compound duplex pump.

BIG VALVES

3—24-in. Atwood standard F.F.D. raising stem gate valves.

1—42-in. Standard F.F.D. Chapman raising stem gate valve.

5—16-in. Standard F.F.D. Kennedy non-raising stem gate valves.

7—24-in. Extra heavy F.F.D. Crane gate valves.

3—8-in. Extra heavy F.F.D. Michigan raising stem gate valves, with by-pass.

Large stock of smaller sizes. Write for list.

Stand Pipe
Water Tower Tank
135 ft. High
20 ft. Diameter

We offer for immediate delivery one Stand Pipe or Water Tower Tank, in excellent condition; located in Chicago.

This tank is 20 ft. in diameter and 135 ft. high. It is made mostly of plates ½, ⅜ and ¼-in. thick, all plates approximately 7½x16 ft. long. Tank is reinforced on the outside with angle iron "Z" bars; includes ladder reaching to top of tank; capacity approximately 320,000 gallons.

The above are selected from a list of one thousand different items in the Machinery Line. Our stock is the largest on earth.

Ask for our Machinery Bulletin PPE-305.

HARRIS BROTHERS CO.
35th and Iron Streets, Chicago.

PUMPS—For Sale

1 Knowles Duplex (steam) 16 x 10 x 12; 60 strokes per minute; 750 gallons against 140 pounds pressure.
1 Knowles Triplex (belt), 5x8.
1 Knowles Triplex (belt), 2x3.
1 American Simplex (steam), 12x18x18.
3 Wagner Duplex, 6x4x6.
1 Davis Duplex (belt), 3x3½.
1 Davis Duplex (belt), 4½x4½.
1 Dean Triplex (gear), 5x8.

Address
RIVER SPINNNING COMPANY
Slater Trust Building,
Pawtucket, R. I.

FOR SALE
1—12x8x10 Worthington Duplex
Steam Pump

rebuilt and guaranteed; 6-in. Suction, 5-in. Discharge; equipped with Hill valve and seats on discharge side.

Ready for Immediate Shipment.

WESTERN FELT WORKS
4115 Ogden Ave., Chicago, Ill.

FOR SALE
STEAM ENGINE

1 Geo. H. Corliss Cross Compound Condensing 18 x 36 x 48. Condensing and at 90 r.p.m., 700 hp. Knowles Twin Vertical Condenser. Entire equipment in excellent condition. Will sell cheap to move quickly.

Address
RIVER SPINNING COMPANY
Slater Trust Building,
Pawtucket, R. I.

BOILERS

2nd Hand—All Sizes and Makes

For Immediate Shipment

J. F. DAVIS
1407 Harris Trust Bldg., Chicago, Ill.

FOR SALE
BOILERS

305 hp. and one 225-hp. Heine water tube boilers, in battery 175 lbs. Hartford insurance. With stokers. Practically new; installed 1912, 2 yrs'. service, $10,000.

POWER MACHINERY EXCHANGE
Jersey City, N. J.

Sparks From The Advertising Pages

Where Buyers and Sellers Meet

"A Great Disaster"

By EDWARD MOTT WOOLLEY

To the readers of POWER PLANT ENGINEERING there is living, burning truth in this message of Edward Mott Woolley. Read these words and act upon them before the facts he presents react upon the very source of your professional information. And in reading these words of one of America's foremost interpreters of business and industrial ideals, incidentally ask yourself: "Am I getting the value from the advertising pages of this journal that this man finds in them?"

A GREAT disaster threatens the readers of trade papers. When the new Zone System of postal rates go into effect next July these papers will be affected more than some other kinds of publications, and this means that their readers will suffer heavily by being shut off more or less from this wonderful fund of information.

Trade papers carry a large proportion of advertising, and therefore the burden of the postal increase, ranging from 50 to 900 per cent, will fall very heavily on them. Now anyone who uses the trade papers knows that the advertising pages, while published for profit, are read for information just as much as the editorial pages. In my own case, I am continually finding wonderful funds of news and fact in trade paper advertisements, as well as in the other pages of these periodicals. If the publishers were to eliminate the advertising and print simply articles, what a vacuous magazine we would have! The advertisements reflect the whole industry represented by any given trade publication. In the aggregate the advertisements of all the trade papers stand as the index of American industry.

Indeed, the status of each industry is presented in undeniable truthfulness every week or month. The merchant or manufacturer can virtually govern his buying and selling by an analysis of these advertising pages.

I have occasion all the time to observe what great educational influence lies in the advertising pages of the trade papers. Once I happened to mention, in one of my articles, a type of device I had seen advertised in a trade magazine. Immediately I received a letter from a man who had never heard of this invention, and he was very much interested. In answering his letter I suggested that if he would read these advertisements he would get much that he would find invaluable in his business.

It goes without saying that this man was the exception, for the very existence of scores of trade papers, with circulations that take in the whole country, proves that the people need them. Shopkeepers, mechanics and students depend upon these journals for their broader knowledge of the particular industry in which they are engaged.

I know of many industrial and mercantile houses where numerous trade papers are kept in the files and where various systems are used in giving the executives, and often the mechanics and workers generally, opportunity to read them. One of these concerns, for instance, has a plan by which certain publications are passed around from man to man, and each is required to return them in a specified time so that others may have them.

That the whole economic prosperity of the country will suffer by the shutting off of trade periodicals is clear enough to those who fully understand their value.

For instance, take the trade convention. We are a nation of convention-goers, and the trade paper gathers all the wisdom and experience expressed in these conventions and places it before thousands of men who are unable to get it first hand. Usually the daily newspapers carry very little of this, because it is technical and intimate to the particular lines of business involved. Without the trade paper it would be lost so far as the mass of workers in any particular field are concerned.

Trade papers, too, are continually printing the reports of investigation of advanced thinkers in merchandising and industrial lines. There is no other medium that would carry these in detail. More often the newspapers do not even make reference to them.

The trade papers employ writers and men of broad experience to go out and get material along the lines of progressive management. I know of one trade paper that sent a man across the continent and back in an automobile to investigate certain merchandising experience. He stopped at scores of towns and gathered, from merchants in widely separated localities, a great fund of information along the line of store operation.

I know of other trade papers that have elaborate and costly organizations for gathering information bearing on forthcoming styles and for reflecting conditions in fabric lines. Without this information the smaller merchants generally would be hopelessly at sea, for only large ones can afford organizations of their own for getting such facts.

There are other publications that are veritable technical schools, in which young men can learn, for instance, the textile business. The young druggist would be in a sad way without his trade paper, in which he finds not only a never-ending flow of business-getting ideas but technical information without which he would speedily fall behind the times. Or take the woodworker. Whether he happens to be an executive, with managerial problems, or a foreman with questions of shop operation, he turns to his own particular trade paper for counsel.

Thus it goes, all through every line of industry. There are hundreds of trade papers. They work quietly and the general public knows little about them, but altogether they constitute one of the most powerful educational agencies.

The ill-advised postal Zone Law will make it impossible for these trade papers to exist in any such form as they do now. Inevitably they must be curtailed so radically that the benefits we now get from them will be largely wiped out. If you don't want this disaster to fall on you, make the fact so plain to your senators and congressmen that they will repeal this destructive Zone Law.

Write to your congressmen to repeal this destructive and disastrous postal "zone" law.